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THE DEVELOPMENT AND LONGEVITY OF HAEMAGOGUS MOSQUITOES UNDER LABORATORY CONDITIONS[1]

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The importance of the mosquitoes of the genus *Haemagogus* in the epidemiology of sylvatic yellow fever led us to undertake laboratory experiments with the mechanism of virus transmission with the Villavicencio species. The results of the virus studies have been published in a series of papers by Bates and Roca (1945a, 1945b, 1946a, 1946b, 1946c), which include some notes on the vector mosquitoes. We became particularly interested in the effect of environmental temperature on the establishment and development of the virus in the mosquitoes, and it seemed that temperature conditions favorable for the virus were also favorable for the mosquitoes. The object of the present paper is to summarize these experiments from the entomological point of view.

Mosquito studies were concerned entirely with the Villavicencio population of *Haemagogus* which, in earlier papers, was erroneously called *Haemagogus capricornii*. The population has recently been named *Haemagogus spegazzinii falco* by Kumm, Osorno and Boshell (1946). The three name types (*capricornii*, *spegazzinii* and *falco*) are remarkably similar mosquitoes, distinguished chiefly by slight morphological characters of the male genitalia. The Villavicencio population seems to be morphologically homogeneous, corresponding to the *falco* type. It has been possible to establish laboratory colonies of certain *Haemagogus* species (Osorno, 1944; Hovanitz, 1946), but all attempts with *falco* have been unsuccessful, due to the failure of the adults to mate under cage conditions. Consequently, our studies have been concerned either with adults caught in the forest or with first genera-

[1]The studies and observations on which this paper is based were conducted with the support and under the auspices of the Institute of Special Studies "Carlos Finlay" maintained by the Ministry of Labor, Hygiene and Social Welfare of the Republic of Colombia and the International Health Division of The Rockefeller Foundation.

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tion material from such adults. Methods of capture, and the results of field studies, have been published previously (Bates, 1944; 1945); laboratory methods of handling infected mosquitoes have been described in some detail by Bates and Roca (1945a) and are the same as those used in the experiments with adults described in the present paper.

SPEED OF LARVAL DEVELOPMENT

Our interest in larval development was primarily practical—to find the most satisfactory method of obtaining adults for experimental purposes. Most of our studies of culture media involved different types of infusion. It is difficult to standardize such infusions so that one experiment can be compared with another, or work at one laboratory repeated in another laboratory. As an example, the results of one set of parallel experiments are summarized in Table I. This shows the

TABLE I

EXPERIMENT WITH GROWTH OF HAEMAGOGUS LARVAE IN VARIOUS CULTURE MEDIA
(100 first stage larvae in 200 cc. of medium, kept at room temperature, mean 25° C.)

Medium	Pupation (Day)					Surviving Larvae on 13th Day	Total Survival through 13th Day
	9	10	11	12	13		
Pure infusion of *Inga* leaves	0	0	0	0	0	36	36
10 per cent *Inga* infusion + breadcrumbs	0	0	0	5	3	43	51
10 per cent *Inga* infusion + dog biscuit	0	0	4	8	10	11	33
10 per cent *Inga* infusion + brewer's yeast	3	10	10	4	6	5	38
Hay infusion (no extra food)	5	16	14	1	13	44	93
Tap water + breadcrumbs	0	0	0	0	0	96	96
Tap water + dog biscuit	0	0	0	0	0	73	73
Tap water + brewer's yeast	1	24	13	12	29	17	96

very considerable difference in rate of growth (as well as in survival) in different media. The infusion of *Inga* leaves (*Inga* is a common leguminous tree of the local forests) was long used as a standard medium in the laboratory; yet as can be seen from this table, certain lots of infusion, at any rate, were very unsatisfactory indeed. Results with brewer's yeast were very consistent, and this was later adopted as a standard medium both for raising larvae and for stimulus of egg hatching. The favorable effect of yeast on the growth of mosquito larvae is well known (e. g., experiments of Trager, 1937), and it is used in many types of routine culture media. We used the dried product put up in tablet form by vitamin manufacturers. While this yeast in tap water seemed to be an entirely adequate food for *Haemagogus capri-*

cornii, it was not sufficient for *Aëdes serratus* or *Psorophora ferox*, though these did well with yeast added to a strong hay infusion.

We made various experiments to determine the effect of temperature on larval growth rate. The results from one set of parallel experiments are summarized in Table II. In this case the larvae were kept individually in shell vials containing tap water to which brewer's yeast was added as food. The amount of yeast was not standardized: rather we attempted to maintain a balance so that some yeast was always present, yet not enough to cloud the water. The yeast, of course, grew more rapidly at high than at low temperatures, so that less was needed at high temperatures. If the yeast grew sufficiently to cloud the water, the larvae were apt to die. The method of feeding each larva separately is subjective, but the results were much more consistent than the results of experiments with known and definite amounts of yeast. In this later type of experiment, a yeast concentration suitable for larvae kept at, say, 20°, would be lethal for larvae kept at 30°. Attempts to grow larvae at a constant temperature of 35° failed, but we do not

TABLE II

GROWTH OF HAEMAGOGUS LARVAE AT VARIOUS TEMPERATURES
(Parallel experiments with 44 larvae in each lot in individual tubes with tap water and brewer's yeast)

Temperature	Average Length of Stages in Days					Total Time Egg to Adult
	I	II	III	IV	Pupal	
20° C.	5.1	2.9	3.1	8.0	6.9	26.0
25° C.	3.4	1.8	2.2	5.7	4.9	18.0
Room temperature (mean 25.5° C.)	2.9	1.3	2.0	4.7	4.1	15.0
30° C.	2.4	1.2	1.6	4.3	3.0	12.5

know whether the failure was the result of a direct effect of the temperature on the larvae, or was caused indirectly by effect on the culture medium.

In the experiments summarized in Table II, the 20° and 30° temperatures were maintained in incubators with fair accuracy, subject only to the hazards of our local power source. The 25° temperature was obtained in a cellar, which during the period of the experiment showed a mean temperature of 24.6°, with an absolute maximum of 25.5° and minimum of 23.0°; the diurnal fluctuation was normally less than 1°. "Room temperature" during the experiment showed a mean of 25.5°, an average maximum of 27.9°, an average minimum of 23.0, an absolute maximum of 30.5° and an absolute minimum of 21.5°. There seems to be a slight acceleration of development under the variable "room temperature" conditions; otherwise the time-temperature curve for *Haemagogus spegazzinii* is similar to that obtained with other species of mosquitoes (e. g., by Headlee, 1942; Hurlbut, 1943; Huffaker, 1944), though development at any given temperature is

slower with *Haemagogus spegazzinii* than with *Aëdes aegypti* or *Anopheles quadrimaculatus*.

The difference in relative length of the four larval stages in mosquitoes is interesting. Possibly the relative length of any given stage is a specific characteristic, since various authors, working with different species, have arrived at different figures (Bates, 1941). In the case of *Haemagogus spegazzinii*, an average of the figures quoted in Table II gives the following proportions for each stage: I, 26 per cent of total larval developmental period; II, 14 per cent; III, 17 per cent; IV, 43 per cent. The distribution under the various temperature conditions is closely similar. The fourth stage seems always to be the longest in mosquito larvae; the possible significance of this has been commented on by Huffaker (1944).

It has often been observed that with mosquitoes, as with other insects, males develop faster than females; but exact figures on the amount of the difference have not come to our attention. The developmental period in the temperature experiments is analyzed by sex in

TABLE III

LENGTH OF DEVELOPMENTAL PERIOD BY SEX IN *Haemagogus spegazzinii*

Temperature	Developmental Period in Days		
	Males	Females	Difference
20° C.	25.6	27.1	1.5
25° C.	17.7	18.2	0.5
Room temperature	14.8	15.4	0.6
30° C.	12.3	12.6	0.3

Table III. To check whether the slowing of female development might be a characteristic of some particular period, such as fourth stage larva or pupa, the data for the 20° group were analyzed in detail. The difference in speed is apparently spread over most of the period of development: the average length of the first stage was the same in both sexes, but the second stage was 0.2 days shorter in males, the third stage also 0.2 days shorter, the fourth stage 0.7 days shorter, and the pupal stage 0.4 days shorter.

SIZE OF ADULTS

It has long been known that the lower the temperature of the larval environment, the larger the adults (within a given species, of course). This is based primarily on the observation that spring mosquitoes in the temperate zone are larger than summer specimens of the same species. The subject became of some importance in Europe with the discovery that size was a differentiating character between two anopheline populations in the Netherlands, one a malaria vector and the other not. The history of this has been reviewed by Swellengrebel and de Buck (1938). Nevertheless there seem to be no published data

on the relation between larval environmental temperature and adult size. To obtain such data, we saved the adults from the temperature experiment summarized in Table II. The right wing and right metathoracic leg of each mosquito were mounted dry on a slide and measured with an ocular micrometer. Various measurements were taken, but the most satisfactory, as a general index of size, seemed to be the wing length measured from the cleft of the alula to the apex—the alula rather than the base of the wing being taken to avoid error because of differences in the point at which the wing was broken. The data from these measurements are summarized in Table IV.

When we realized how much larger and how much hardier the mosquitoes raised at 20° were than those raised at higher temperatures, we adopted 20° as a routine temperature for raising adults for a series of attempts at colonizing the species. Unfortunately, we did not make any clearly comparable tests of adult longevity of mosquitoes raised at

TABLE IV

RELATION OF LARVAL TEMPERATURE TO ADULT SIZE
(Length of wing, from cleft of alula to apex in mm.)

Temperature	Males		Females	
	No. Specimens	Length and Standard Deviation	No. Specimens	Length and Standard Deviation
20° C.	17	2.69 ± .09	16	3.21 ± .06
25° C.	14	2.56 ± .07	21	3.01 ± .08
Room temperature	21	2.61 ± .07	13	3.01 ± .05
30° C.	18	2.43 ± .08	12	2.84 ± .05

various temperatures, but we had a clear impression that the 20° adults survived adverse conditions much better than those raised at room temperature or at 30°: they were more active in cages, bit more readily (even though unfertilized) and withstood periodic exposures to high temperatures such as would result from leaving the cages for half an hour or more daily in bright sunshine. We did not succeed, however, in inducing sexual activity in such adults.

ADULT LONGEVITY UNDER LABORATORY CONDITIONS

Mosquitoes of the genus *Haemagogus* were early suspected as vectors of sylvatic yellow fever, but attempts to obtain virus transmission in the laboratory failed because of difficulty in keeping the mosquitoes alive through the extrinsic incubation period of the virus (Kumm and Frobisher, 1932; Antunes and Whitman, 1937). In these early experiments conventional methods of maintaining mosquitoes were used: the mosquitoes were kept in cages, "protected from the wind and covered with a layer of wet absorbent cotton in order to increase the humidity" (Antunes and Whitman). We used similar methods and obtained similar results: most mosquitoes died in five or six days, and only an

occasional specimen would live through the presumed incubation period of the virus. We found that longevity could be increased if the mosquitoes were kept at low temperatures (20°), but this was of little help since the extrinsic incubation period of the virus would also be greatly prolonged. We made a great many experiments, attacking the problem from various points of view, such as frequency of blood meals, type of food other than blood, type of cage, humidity and temperature; and we eventually worked out quite satisfactory techniques for our purposes. For the most part, these experiments were not controlled with sufficient care to be of value for the analysis of problems of mosquito physiology, and there is no point in summarizing them in detail. They do, however, illustrate the difficulty of laboratory experimentation with problems like longevity, and they demonstrate the specific nature of the physiological adaptations that govern longevity under laboratory conditions, since techniques that were successful with *Haemagogus spegazzinii* were unsuccessful with other diurnal forest mosquitoes and vice versa.

The literature on factors governing insect longevity is enormous, and a very considerable number of studies have been made of the survival of various mosquito species under laboratory conditions. The subject is of obvious practical importance, since the efficiency of a given species as a vector of disease depends, in part, on its relative longevity. Because the study of longevity in nature is very difficult, laboratory study offers a promising line of attack. Outstanding studies of this type, with general reviews of the literature, are those by Russell and Rao (1942) and Sinton and Shute (1938).

The method that we eventually adopted for the maintenance of infected haemagogus has been described in detail in a previous article (Bates and Roca, 1945a). Essentially it consisted in keeping the mosquitoes in individual flat-bottomed glass vials (25x50 cm. in size) with a layer of moist cotton in the bottom covered with a disc of filter paper (to prevent the mosquitoes' getting entangled in the cotton) and plugged with a cup of aluminum (or monel) wire screening containing a small wad of cotton soaked in sugar solution for food. The vials were kept in racks in an environment with air in constant movement: we put fans in all incubators, and when mosquitoes were kept in open rooms, we found it advisable to place them near an electric fan. It seemed, in other words, important that the mosquitoes have a source of moisture always available (the wet cotton in the bottom of the vials) but that they be maintained in a relatively dry atmosphere (usually about 70 per cent relative humidity) with the air in constant movement. Satisfactory survival could also be obtained in a cage with large numbers of mosquitoes if the bottom was covered with moist cotton, and the cage kept near a fan.

We made a total of 290 infection experiments with yellow fever virus in mosquitoes, principally *Haemagogus spegazzinii*. Most of these experiments are of no use for longevity studies, however, since specimens were removed and killed at varying intervals to test for virus development. In some cases the "control" mosquitoes showed that the lot had received no virus, and such lots were often kept specifically for longevity tests. Also, as a general rule, no mosquitoes were

removed from an infected lot during the first 10 days; thus comparison can be made of percentage of survival in the 10-day period under various environmental conditions.

It is interesting that the method of individual vials was satisfactory only with diurnal forest mosquitoes of the canopy zone, such as *Haemagogus* and *Sabethoides* (Bates, 1944); mosquitoes of the forest floor zone, such as *Aëdes serratus* and *Psorophora ferox* required quite different treatment. Thus one lot of 26 *Aëdes serratus* kept under standard haemagogus conditions in vials at a constant temperature of 30° had a mean life of 4.9 days and a maximum survival of 7 days; the mean life *Haemagogus spegazzinii* under identical conditions was 13.8 days (based on 512 specimens in 14 experiments), with maximum survival about 50 days. In 42 different lots of *spegazzinii* kept under these conditions, survival after 10 days was almost always over 50 per cent, with an average survival for this period of 63 per cent.

On the other hand, *Psorophora ferox* and *Aëdes serratus* showed excellent survival in small cages in a subterranean room where the

TABLE V

SURVIVAL OF MOSQUITOES IN SMALL CAGES IN SUBTERRANEAN ROOM
(Temperature fairly constant at 25°)

Species	No. Experiments	No. Mosquitoes	Survival in Days	
			Mean	Average Maximum
Haemagogus spegazzinii.....	8	295	7.6	13.3
Aedes serratus.....	5	138	26.7	51.8
Psorophora ferox.....	5	86	20.8	36.8
Psorophora cingulata.....	4	135	13.4	25.8

temperature was quite constant at 25°, and the humidity nearly saturated. Data from a series of comparable experiments under these conditions with three diurnal forest mosquitoes and one crepuscular species (*Psorophora cingulata*) are summarized in Table V. Under these conditions, one would judge *Aëdes serratus* to be a long-lived species and *Haemagogus spegazzinii* a short-lived one—precisely the opposite of the results obtained under the conditions described in the preceding paragraph.

The experiments mentioned above were all made with mosquitoes caught as adults and brought to the laboratory. They were thus of unknown age at the start of the experiment. Longevity experiments with such mosquitoes, however, gave quite consistent results; in the case of *Haemagogus spegazzinii*, transmission experiments were made with wild caught mosquitoes throughout the year, with no difference in average survival from one time of year to another. There was, however, a very great difference in survival between wild caught haemagogus and specimens raised in the laboratory at 30°, with yeast as larval food. Four hundred and four such specimens were used in infection exper-

iments; only 28 per cent survived the first 10 days in vials at 30°, in contrast with an average survival of 63 per cent of wild caught specimens (based on 1,423 specimens) over the same period. Comparable experiments were not made with adults bred from larvae kept at lower temperatures, but as remarked above, we have the impression that such adults were much hardier. At any rate, it is clear that in the case of laboratory-bred mosquitoes, the larval culture conditions may have a controlling influence on adult longevity.

It has often been demonstrated that virus infection has no obvious adverse effect on the vector mosquito. To check this a series of 27 consecutive infection experiments in which haemagogus were maintained in vials at 30° were selected and divided into three categories: first those in which the source animal was subsequently found not to have circulated virus at the time of the experiment, so that the mosquitoes were uninfected; second, those in which the source animal was circulating only a small amount of virus, so that few mosquitoes were infected; and third, those in which the source animal was circulating a

TABLE VI

AVERAGE SURVIVAL IN DAYS OF *Haemagogus spegazzinii* IN INDIVIDUAL TUBES UNDER VARIOUS TEMPERATURE CONDITIONS

Temperature	No. Experiments	No. Mosquitoes	Average Survival
20° C. constant	3	66	19.4
25° C. constant	3	128	18.3
26.6° C. (20 Hr. 25° C, 4 Hr. 35° C.)	3	154	14.5
30° C. constant	14	512	13.8
35° C. constant	3	132	4.8

large amount of virus, so that about 90 per cent of the mosquitoes were found to be infected. After 10 days, 60 per cent of 334 non-infected mosquitoes, 74 per cent of 283 partially infected mosquitoes, and 60 per cent of 784 heavily infected mosquitoes were still alive.

EFFECT OF TEMPERATURE ON HAEMAGOGUS ADULTS

The effect of temperature on the development of virus in haemagogus mosquitoes has been discussed in a previous paper (Bates and Roca, 1946b). Transmission experiments were carried out routinely at constant temperature of 30°; but since such temperature conditions would be unknown in nature, we made a few transmission experiments at various other constant and alternating temperatures. We found that virus development in mosquitoes kept for 20 hours at 25° and four hours at 35° daily was almost as rapid as that in mosquitoes kept at 30° constantly. In one set of parallel experiments, for instance, the minimum incubation period for the virus was 28 days at 25°, 23 days at 25°–30°, 12 days at 25°–35°, and 10 days at 30°. We failed to get transmissions at constant temperatures of 20° or 35°. It thus appeared that the four-hour daily exposure to 35° had a very considerable accel-

erating effect on virus development not explainable by the mean temperature, which calculated on an hourly basis would be 26.6°. We thought it would be interesting to attempt to measure the effect of these temperature conditions on the mosquito.

The average survival of haemagogus mosquitoes in individual vials under various temperature conditions is summarized in Table VI. The figures are based on few experiments and relatively few specimens; but the results with various individual experiments are quite consistent, and the survival figures are probably significant. It is interesting that survival is shortened by the four-hour daily exposure to 35° below what would be expected from the hourly mean (26.6°).

As a check on the influence of temperature on a physiological process in the mosquito, we kept detailed records on oviposition in several experiments. The results are summarized in Table VII. These mosquitoes all engorged on a monkey at the start of the experiment (the

TABLE VII

OVIPOSITION OF HAEMAGOGUS UNDER VARIOUS TEMPERATURE CONDITIONS
(88 mosquitoes in each lot)

	TEMPERATURE			
	25° C.	25° C.-35° C.	30° C.	35° C.
Per cent alive at 10 days.....	53	47	43	2
Average day of first eggs....	7.2	6.2	6.2	6.5
Per cent laying eggs.....	61	57	39	5
Total number eggs in 10 days	1144	1121	742	57
Number eggs per mosquito laying.....	21	22	22	11

infectious meal) and subsequently received no food except sugar solution. It is interesting that the number of mosquitoes laying eggs and the number of eggs laid are practically the same at 25° constant temperature, and at the 25°–35° alternating temperature. Egg development, however, is speeded up by the daily exposure to 35°, being the same (6.2 days) as in mosquitoes kept at a constant temperature of 30°. Egg development in the mosquito seems to act like virus development. The number of mosquitoes laying eggs is appreciably reduced at the constant temperature of 30°, more so than would be explicable by the increased mortality. The number of eggs per mosquito laying, however, remains the same: in other words, a certain proportion of individuals are inhibited from oviposition by the constant temperature of 30°. A constant temperature of 35° seems to be very unfavorable for *Haemagogus spegazzinii* from every point of view.

DISCUSSION

Haemagogus spegazzinii is a diurnal forest mosquito with a peak of activity toward mid-day; it is found most abundantly in the forest canopy or in open sunny clearings or around forest margins. Its bright

metallic coloration may be an adaptation to this relatively dry and warm environment. The larvae have been found in tree-holes, most commonly in holes with very narrow apertures; they are scarce in relation to the number of adult mosquitoes, and it seems likely that the chief breeding place is some type of tree-hole or container habitat that has been overlooked in forest studies. Conditions favorable for haemagogus survival in the laboratory are very different from conditions favorable for the survival of the mosquitoes of the forest floor zone (*Psorophora ferox* and *Aëdes serratus*), and it is difficult to avoid the conclusion that these laboratory differences reflect physiological adaptations to the different natural environments. A constant high relative humidity seems to be definitely unfavorable for haemagogus and these mosquitoes are very short lived when kept in a subterranean room in small cages with added moisture—conditions that seem to be ideal for the mosquitoes of the forest floor zone (Table V). The mean life in cages in such a room was 7.6 days; whereas at the same temperature (25°) in individual vials with screen stoppers, in an incubator provided with an electric fan, the mean life was 18.3 days (Table VI). It is well known that many mosquitoes avoid extremely high humidities (Thomson, 1938), but in general the higher the humidity, the longer the survival (Hundertmark, 1938; Leeson, 1939). It would be interesting to investigate the mechanism of the unfavorable effect of the cellar environment on haemagogus.

The correspondence between conditions favorable for haemagogus mosquitoes and conditions favorable for yellow fever virus is interesting. A constant temperature of 30° was very favorable for virus development, but relatively unfavorable for the mosquitoes; twenty hours daily at 25° and four hours at 35°, however, proved to be almost equally favorable for the virus, and much better for the mosquitoes than the constant temperature. It is very likely that the mosquito would be subject to an alternating temperature of this order of magnitude in nature, since 25° is close to the mean forest temperature at the floor zone, where conditions are quite constant day and night, and 35° is a very likely body temperature for daily periods of activity in a sun-loving mosquito like haemagogus.

It is interesting to speculate as to the possible nature of the "optimum" temperature for these various processes. With regard to larval development, the "optimum" is generally considered to be the temperature at which the greatest speed of development coincides with a minimum mortality (e. g., Mosna, 1937) or perhaps the highest temperature at which clearly adverse effects are not apparent. Yet "optimum" carries the connotation of "most favorable for the species," which surely involves many factors other than mere speed of growth. In haemagogus, for instance, the size (and apparently the hardiness) of the adult is in part a function of the larval temperature, and this would have to be taken into account in attempting to determine what larval temperature would be most favorable for the species. In the case of adults, survival under protected conditions is longer the lower the temperature, but in nature this longer survival might be counterbalanced by the slowing up of physiological processes such as egg development, and the consequent greater hazard of accident to the

mosquito before these processes were carried through. In this case, the highest temperature at which adverse effects are not demonstrable might well be the "optimum" for the species. That such adverse effects appear is shown by the decreased oviposition, for instance, at 30° and 35° in the present studies. The fact that egg development proceeds at the same rate at the 25°–35° alternation of temperature as at the constant temperature of 30°, and that oviposition and survival are much greater at the alternating temperature, might well be taken as indicating that some such conditions as these were "most favorable for the species." They are certainly most favorable for the virus!

SUMMARY

Experiments were carried out testing the effect of food and larval temperature on the development of *Haemagogus spegazzinii*. Brewer's yeast was found to be an excellent food for this species, though inadequate for *Aëdes serratus* or *Psorophora ferox*. Larval development required 26 days at 20°, 18 days at 25° and 12.5 days at 30° C. Adults developing from larvae kept at lower temperatures were larger (and apparently hardier) than those from larvae kept at higher temperatures. Data are given on the difference in size. Of the total period of larval development, 26 per cent was spent in the first stage, 14 per cent in the second, 17 per cent in the third, and 43 per cent in the fourth, the proportions being the same at the various temperatures tested. The males developed faster than the females, the increase in developmental speed being demonstrable from the second larval stage on.

Survival of *Haemagogus spegazzinii* was very unsatisfactory with mosquitoes kept in cages provided with moisture and maintained in a room at 25° with a high relative humidity. Survival of mosquitoes of the forest floor zone (*Aëdes serratus, Psorophora ferox, P. cingulata*) was excellent under these conditions. *Haemagogus* seemed to require an adequate supply of available mositure, but a relatively dry atmosphere; and best results were obtained with mosquitoes in individual screen-stoppered vials with constant air movement provided by an electric fan. Survival of *Aëdes serratus* and simiilar mosquitoes was very poor under these conditions.

Survival of haemagogus adults bred from larvae kept at 30° was very poor, as compared with survival of wild caught adults. Infection with yellow fever virus had no effect on adult longevity.

In general, the lower the temperature, the longer the survival of adults within the range tested (20°–35°). Unfavorable effects measurable in decreased oviposition were apparent at 30° and 35°. Speed of egg development (and virus development) was almost the same at an alternating temperature of 20 hours daily at 25° and 4 hours at 35° as at a constant temperature of 30°; the proportion of specimens ovipositing and the average length of life were both greater at the alternating temperature. The difference between behavior at 25° and at the 25°–35° alternation cannot be accounted for by the increase in mean temperature, since this, calculated on an hourly basis, was only 26.6°.

The relation between the laboratory results and the habits of the mosquito in nature is discussed, together with some comment on the significance of the concept of "optimum temperature."

REFERENCES

Antunes, P. C. A., and **L. Whitman.** 1937. Studies on the capacity of mosquitoes of the genus *Haemagogus* to transmit yellow fever. Am. J. Trop Med., 17: 825–831.

Bates, M. 1941. Field studies of the anopheline mosquitoes of Albania. Proc. Entomolog. Soc. Washington, 43: 37–58.

1944. Observations on the distribution of diurnal mosquitoes in a tropical forest. Ecology, 25: 159–170.

1945. Observations on climate and seasonal distribution of mosquitoes in eastern Colombia. J. Animal Ecology, 14: 17–25.

Bates, M., and **M. Roca-Garcia.** 1945a. Laboratory studies of the saimiri-haemagogus cycle of jungle yellow fever. Am. J. Trop. Med., 25: 203–216.

1945b. The douroucouli (*Aotus*) in laboratory cycles of yellow fever. Am. J. Trop. Med., 25: 385–389.

1946a. Experiments with various Colombian marsupials and primates in laboratory cycles of yellow fever. Am. J. Trop. Med., 26: 437–453.

1946b. The development of yellow fever virus in haemagogus mosquitoes. Am. J. Trop. Med., 26: 585–605.

1946c. An experiment with neurotropic yellow fever virus in saimiri monkeys and haemagogus mosquitoes. Am. J. Trop. Med., 26: 607–612.

Headlee, T. J. 1942. A continuation of the studies of the relative effects on insect metabolism of temperature derived from constant and varied sources. J. Econ. Entomol., 35: 785–786.

Hovanitz, W. 1946. Comparisons of mating behavior, growth rate, and factors influencing egg-hatching in South American *Haemagogus* mosquitoes. Physiological Zoölogy, 19: 35–53.

Huffaker, C. B. 1944. The temperature relations of the immature stages of the malarial mosquito, *Anopheles quadrimaculatus* Say, with a comparison of the developmental power of constant and variable temperatures in insect metabolism. Ann. Ent. Soc. Amer., 37: 1–27.

Hundertmark, A. 1938. Ueber das Luftfeuchtigkeitsunterscheidungsvermögen und die Lebensdauer der 3 in Deutschland vorkommenden Rassen von *Anopheles maculipennis* bei verschiedenen Luftfeuchtigkeitsgraden. Z. angew. Ent., 25: 125–141.

Hurlbut, H. S. 1943. The rate of growth of *Anopheles quadrimaculatus* in relation to temperature. J. Parasitol., 29: 107–113.

Kumm, H. W., and **M. Frobisher, Jr.** 1932. Attempts to transmit yellow fever with certain Brazilian mosquitoes (*Culicidae*) and with bedbugs (*Cimex hemipterus*). Am. J. Trop. Med., 12: 349–361.

Kumm, H. W., E. Osorno-Mesa, and **J. Boshell-Manrique.** 1946. Studies on mosquitoes of the genus *Haemagogus* in Colombia. Am. J. Hyg., 43: 13–28.

Leeson, H. S. 1939. Longevity of *Anopheles maculipennis* race *atroparvus*, van Thiel, at controlled temperature and humidity after one blood meal. Bull. Ent. Res., 30: 295–301.

Mosna, E. 1937. Sulle caratteristiche termiche dei focolai di *Anopheles maculipennis*. Riv. Parassit., 1: 139–155.

Osorno-Mesa, E. 1944. Organización de una colonia de *Haemagogus equinus* Theobald. Caldasia (Bogotá) 3: 39–45.

Russell, P. F., and **T. Ramachandra Rao.** 1942. Observations on longevity of *Anopheles culicifacies* imagines. Am. J. Trop. Med., 22: 517–533.

Sinton, J. A., and **P. G. Shute.** 1938. A report on the longevity of mosquitoes in relation to the transmission of malaria in nature. London: Ministry of Hlth. Rpts. Pub. Hlth. and Med., Subject no. 85, 45 pp.

Swellengrebel, N. H., and **A. de Buck.** 1938. Malaria in the Netherlands. Amsterdam: Scheltema & Holkema Ltd., viii+267 pp., 23 figs., 2 pls.

Thomson, R. C. M. 1938. The reactions of mosquitoes to temperature and humidity. Bull. Ent. Res., 29: 125–140.

Trager, W. 1937. A growth factor required by mosquito larvae. J. Exp. Biol., 14: 240–251.

BUTTERFLY AGGREGATIONS IN TEMPERATE REGIONS

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The idea prevails that butterflies generally lead solitary lives. In the tropics, however, at certain seasons, aggregations of them often appear on the landscape. They are usually quite conspicuous and colorful, and not only are they of frequent occurrence, but also they often comprise immense numbers of individuals.[1]

Aggregations of butterflies also occur in temperate lands, but are overlooked for the most part by behavior students because of their less frequent occurrence, the small size of the congregations and their lack of brilliant colors. But regardless of the region in which the butterflies live, the impulse for sociability is quite the same and has, so far as I can see, nothing at all to do with food or courtship.

As an example of butterfly aggregations in temperate regions, I am glad to record an observation in St. Louis County where, on the sunny afternoon of September 13, 1942, I found along a half-mile stretch of a partially dry creek-bed, about twenty-five aggregations of four species of butterflies.[2] The participants in the little drama were:

The black and red, *Phycoides tharos* Drury (Fam. Nymphalidae).
The small Sulphur, *Eurema lisa* Bdv. & LeC. (Fam. Pieridae).
The large Sulphur, *Catopsila eubule* Linn. (Fam. Papilionidae).
The small blue *Everes comyntas* Godt. (Fam. Lycaenidae).

The number of individuals in these aggregations varied greatly; no two groups were alike. However, they fell roughly into four categories, a sample of each of which is herewith presented.

AGGREGATION A

This is a sample of seven groups made up of rather definite units, this particular major group having eight parts, as follows:

Unit No. 1. 150 *E. comyntas*—Blue.
Unit No. 2. 12 *E. lisa*, 1 foot East of Unit 1—Small Sulphur.
Unit No. 3. 1 *E. lisa*, 3 feet North of Unit 1—Small Sulphur.
Unit No. 4. 50 *E. comyntas*, 2 feet West of Unit 1—Blue.
Unit No. 5. 12 *E. lisa*, 12 feet West of Unit 4—Small Sulphur.
Unit No. 6. 3 *P. tharos*, 2 feet South of Unit 5—Black and Red.
Unit No. 7. 7 *E. lisa*, 3 feet North of Unit 5—Small Sulphur.
Unit No. 8. 2 *P. tharos*, 2 feet West of Unit 6—Black and Red.

In this sample aggregation we have representatives of three species, comprising 237 individuals, resting in eight small, irregular groups near

[1]See "Clouds of Butterflies in Mexico. A Study on Butterfly Aggregations." Entom. News 53: 121-126, 151-154, 181-184, 1942.
[2]The butterflies were kindly identified by Mr. Carl Heinrich.

to one another. Friendliness seemed to be the order of the day, yet there was absolutely no intermingling of the species; each species kept strictly to itself.

AGGREGATION B

Here is a sample of another kind of group which appeared six times on the half-mile of creek-bed. The group consisted mainly of about 85 small Sulphurs, *E. lisa*, but scattered among them were a dozen large Sulphurs, *C. eubule*. The small butterflies have black markings on the wings, but when at rest with the wings erect the marks are concealed. Both species together, therefore, form a solid mass of yellow. In every case among the six "combination aggregations" on the creek-bed, the large Sulphurs were greatly in the minority. The largest group of this kind had 115 *E. lisa* and 15 *C. eubule*. There were also several groups composed entirely of the small *E. lisa*, but no instance was found of *C. eubule* forming a group alone; they were always in company with the small Sulphurs.

AGGREGATION C

The blue *E. comyntas* was by far the most abundant in the area. In addition to congregations of these in close proximity to the other species, there were often groups of from 10 to 50 in places isolated from all other groups of their own or other species.

AGGREGATION D

The black and red *P. tharos* were in the minority. In addition to a few small gatherings of them near other groups, there were sometimes isolated groups of only 2 to 5 individuals.

DISCUSSION

The observations show that while all four species were gregarious, two of them, *P. tharos* and *E. comytas*, kept strictly to themselves in groups of their own species. The same was also true in only part of the cases for the small Sulphur, *E. lisa*, but the latter often permitted the large Sulphur, *C. eubule*, to enter its groups. The large Sulphurs, in this locality at least, were never found in a group of their own species exclusively, but joined the groups of the small Sulphurs. Here it appears that color perception may be a factor to bring the two yellows together, and this in spite of the fact that the two kinds of butterflies belong to distinct taxonomic groups. These few observations, however, give us no evidence as to whether color perception or olfactory recognition brings each species into groups of its own kind.

An equally important aspect of this habit of assembling is its relation to societal evolution. The gregariousness that we note in butterflies may be low in the scale of psychic development, but nevertheless their predilection for sociability may yet prove to be one of the early steps in the scheme of the evolution of social life among insects.

EMBRYOLOGY OF LUCILIA SERICATA MEIGEN
(Diptera: Calliphoridae)

PART I. CELL CLEAVAGE AND EARLY EMBRYONIC DEVELOPMENT

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Investigations in insect embryology can be traced back to the early 19th century which period included the works of Herold (1815) on Lepidoptera and Humel (1835) on the roach. In 1843 Kölliker published a comparative study of insect and vertebrate development. The first comprehensive work on dipterous embryology was that of Weismann (1863). Kowalewsky (1871) whose research dealt with worms and arthropods was the first investigator to study fixed and sectioned material. Graber's (1879, 1888, 1889, 1890) works on muscid development represent probably the most extensive treatise on dipterous embryology. Gambrell (1933) lists the Diptera whose development has been studied up to 1932. A complete list of references dealing with dipterous embryology is contained in Johannsen and Butt (1941). The embryology of several species of *Lucilia* has been investigated by Graber (1881, 1889), Escherich (1900, 1902) and Noack (1901) but apparently no study has been made on the development of *Lucilia sericata* Meigen.

The purpose of this research is the determination of the exact nature of cell cleavage and the migration of the cleavage cells to the egg periphery in *Lucilia sericata*.[2]

MATERIALS AND METHODS

Lucilia sericata, the sheep blow-fly, was selected as the subject of this embryological investigation because of the abundance of available material, the ease of egg collection and the size of the egg. The chief difficulty encountered was the rapidity of development as some of the eggs complete their development in as quickly as 15 hours (24 hours is about the average). This difficulty was remedied by two measures: first, by collecting eggs every five minutes and second by taking large samples of eggs thereby assuring a complete series of developmental stages. Approximately 250 eggs were fixed and sectioned for this study.

The eggs necessary for this investigation were obtained from stock cultures of flies reared in the insect rearing room in the sub-basement of the Botany and Zoology Building, Ohio State University. Two-day-old

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[2]The writer wishes to express his gratitude to Professor Clarence H. Kennedy, who directed this research, for his suggestions, recommendations and criticisms; to Louis M. Roth, for his aid with plate arrangement and critical review of this manuscript.

pupae were selected which were placed in a glass rearing cage. After emergence the adults were given a diet of lean hamburger, rock candy crystals and water. Oviposition began about the fifth day. Of the females observed the eggs were laid in clusters on the sides and undersurfaces of the meat. Each cluster consisted of from 6–7 eggs to, in many cases 75–100. Immediately after oviposition of several clusters (from 1 to 3 minutes) the egg masses were removed to a temperature of 21° to 22° C. They were fixed immediately upon deposition and at intervals of five minutes thereafter up to four hours. The eggs were fixed in hot Bouin's fixative. This fixing fluid was heated in small glass vials in a water bath of 70° C. Immediately after the placement of eggs in the fluid the vials were removed from the bath and allowed to cool at room temperature. After remaining in the fixative for 4 hours they were washed in 70% alcohol until the yellow color of picric acid disappeared and then stored in 70% alcohol.

To facilitate handling during infiltration and imbedding it was necessary in most cases to stain first in toto. The following stains were used: Grenacher's Borax Carmine, Delafield's Haemotoxylin in various proportions with water, Eosin, Aniline Blue and Acid Fuchsin. Delafield's Haemotoxylin, 1 part to 3 parts water, was the most rapid and consistent. It was necessary to remove both the chorion and vitelline membrane for quick and uniform staining in all eggs more than 15 minutes old.

After several weeks storage in alcohol the vitelline mass will shrink appreciably away from both the chorion and vitelline membrane. This shrinkage was most noticeable at the poles. The chorion in most cases could be incised at either pole with a minute nadel and the egg with its vitelline membrane popped out of the incision. If appreciable shrinkage has occurred at the poles the vitelline membrane could be removed in a fashion similar to that of the chorion. In cases where it still contacted the vitellus at the poles it could be peeled off by holding the egg firmly in place with one minute nadel and peeling with the other. Frequently tearing of the egg would occur in the area of initial peeling so it became necessary to vary the location of this area in each age group studied. In a few cases mild shaking of the vial would remove both the chorion and vitelline membrane.

The schedule for dehydration prior to clearing and infiltration depended on the stain used. Aqueous stains (in toto) were followed by: 35% alcohol 5 minutes; 70% alcohol 5 minutes; 95% alcohol 10 minutes; 100% alcohol 30 minutes; 2 parts 100% alcohol, 1 part cedar oil 60 minutes; 1 part 100% alcohol, 2 parts cedar oil 60 minutes; pure cedar oil until clear, usually one hour to overnight. To insure complete dehydration and for convenience the majority of eggs were cleared overnight. Clearing for several days in cedar oil did not seem to be harmful to the egg structures. Before the transfer from the clearing agent to paraffin the eggs were briefly rinsed in xylene to remove the film of cedar oil on the egg surface.

The period of infiltration varied from 1 to 5 hours with no apparent differences noted either during sectioning or in sectioned material. The summer paraffin mixture (56°–58° C.) was used successfully in most cases. Four methods of imbedding were employed; the paper

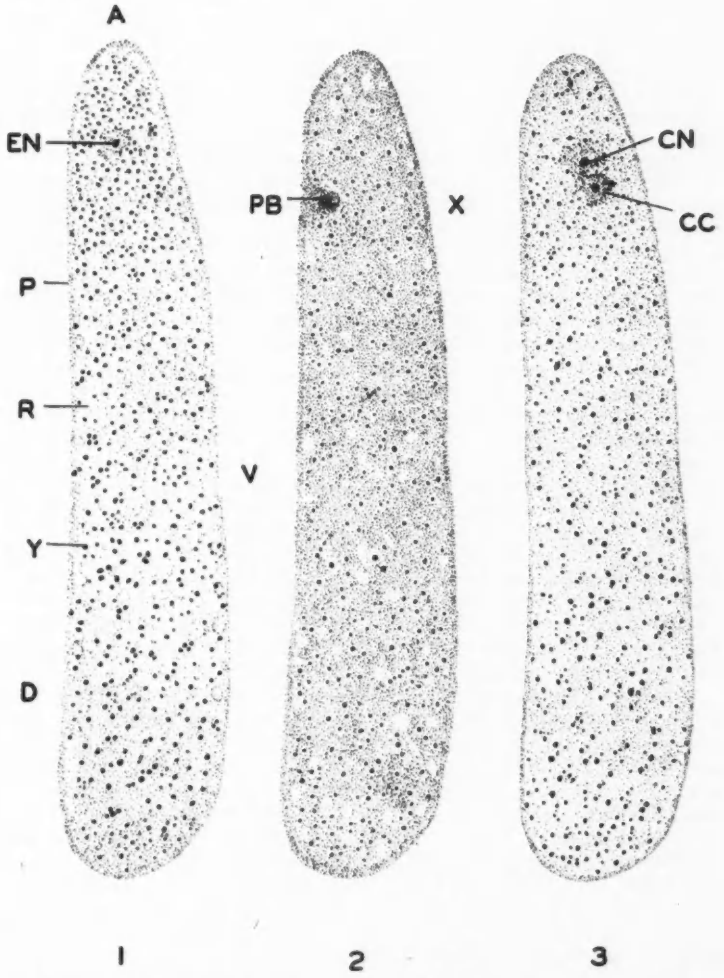


FIG. 1. Age 1–5 minutes. Egg nucleus centrally located prior to reduction division. A—anterior; D—dorsal; EN—egg nucleus; P—periplasm; R—reticulum; V—ventral; Y—yolk.

FIG. 2. Age 5–15 minutes. Egg nucleus moves to periphery. Reduction division occurs here. Clear areas indicate vitelline spheres. PB—polar body.

FIG. 3. Age 5–15 minutes. Two-cell stage; nuclei centrally located. CC—cleavage cell; CN—cleavage nucleus.

box, Syracuse watch glass, the bottom portion of a small glass vial, and small (about ½ inch diameter) cups made from celluloid. The latter proved by far the most advantageous because of its ideal size and flexibility. Both the temperature controlled oven and the table lamp methods of heat source for infiltration were used with the latter more satisfactory and convenient. Accurate orientation was not attempted during imbedding in order to prevent crystallization of the paraffin in the region of the future embryo; this sometimes happens when hot needles were used for orientation in imbedding. The eggs were removed from the infiltration mass by means of torn edges of filter paper and quickly dropped into the melted imbedding mass in the celluloid cup. The eggs sank to the bottom of the paraffin mixture which had been previously chilled for about three seconds in ice water. Immediately after the egg came to rest horizontally the liquid paraffin surface was breath-blown solid and the cup was immersed in chilled water. Using two of these cups ten embryos could be imbedded in as many minutes.

The paraffin blocks each containing one embryo were trimmed until their thickness did not exceed over three times the diameter of the embryo. Thus the outline of the stained embryo was clearly visible. Final orientation was accomplished during sectioning by adjusting the "swivel joint" containing the block holder. The width of the sections varied from 2 to 9 microns depending on whether structure or location of cleavage cells was desired; 5 microns were satisfactory for most stages. The sagittal sections were best prepared by cutting with the blade parallel to the longitudinal axis of the egg. The ribbons were mounted on glass slides treated with egg albumen by flotation on cold water and spreading was accomplished by placing a heated slide directly underneath or by direct flame from an alcohol burner. All air bubbles were removed from the spread sections with warm fine needles. The slides were dried overnight at room temperature.

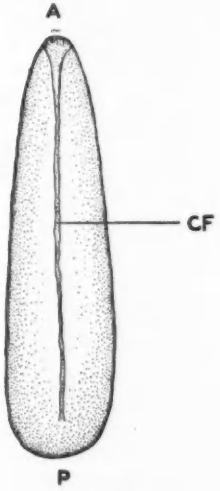
Various stains were employed to determine the early nuclear arrangements and cell migration prior to the formation of the blastoderm. The following were tested: Delafield's Haemotoxylin in various proportions with water, Delafield's Haemotoxylin followed by Eosin, acid Delafield's Haemotoxylin, Heidenheim's Iron Haemotoxylin singly or followed by picric acid or Masson's triple stain (Aniline Blue, Phosphomolybic Acid and Acid Fuchsin) and Mayer's Carmalum. When Heidenheim's Iron Haemotoxylin was used singly the schedule given by Kennedy (1932) was followed; when followed by Picric Acid that of Auten (1934). The better preparations were obtained with the haemotoxylins used separately. The sections were cleared in xylene, mounted in dilute balsam and dried overnight at 40° C.

Plates I, II, III and IV are composite drawings of longitudinal sections.

THE EGG

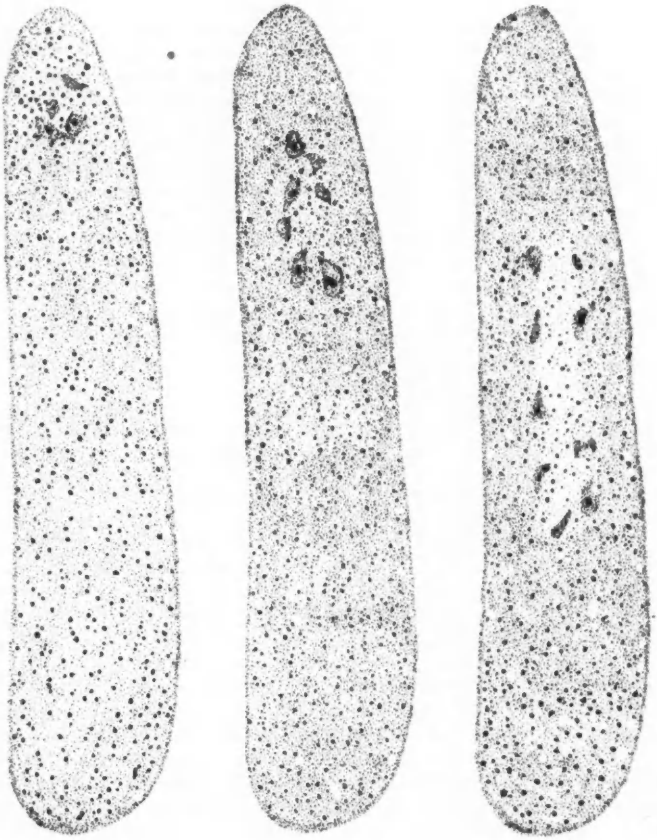
The egg of *Lucilia sericata* is elongate (about 1380 microns), pearly white with a slightly flattened dorsal surface and a decidedly convex ventral surface. The anterior pole (about 190 microns) in most cases

is strongly curved and almost pointed while the posterior pole (about 280 microns) is but gently curved and broadly rounded. The egg is covered on the outside by a complicated chorion which in surface view consists of a network of polygonal impressions and in cross section of a thin outer smooth layer and an anastomosing inner layer. (Pl. VI, fig. 23). Except in the region immediately underlying its two dorsal folds the chorion lies in close contact with the vitelline membrane, a thin non-cellular membrane lying below the chorion. Immediately after deposition the chorion is very soft and pliable and easily permeated by haemotoxylin stains. At this stage there is little if any indication of the vitelline membrane which hardens into a definite structure after about 15 minutes.



Text Figure 1

The egg proper consists of the (1) periplasm, a definite thin outer layer of formative protoplasm slightly thicker at the poles, (2) a reticular layer of protoplasm in which the deutoplasm or yolk is contained, and (3) a single egg nucleus surrounded by nuclear protoplasm, located in the anterior third of the egg. (Pl. I, fig. 1). In the dorsal region of the posterior pole the periplasm contains the oosome, (Pl. III, fig. 9; Pl. VI, figs. 20, 21), a special inclusion which bears a direct relationship to the primordial germ cells. In fixed and stained preparations the deutoplasm consists of deeply staining yolk bodies in the form of spheres of various diameters and of spheroid cavities which are indicative of the regions occupied by the vitelline spheres. These vacuolated spaces probably represent yolk material soluble in either the fixing fluid or in one of the chemicals used in tissue preparations.



4 5 6

FIG. 4. Age 15–30 minutes. Four-cell stage; three nuclei shown.
FIG. 5. Age 30–45 minutes. Eight-cell stage; four nuclei shown.
FIG. 6. Age 30–60 minutes. Sixteen-cell stage; cell configuration medial.

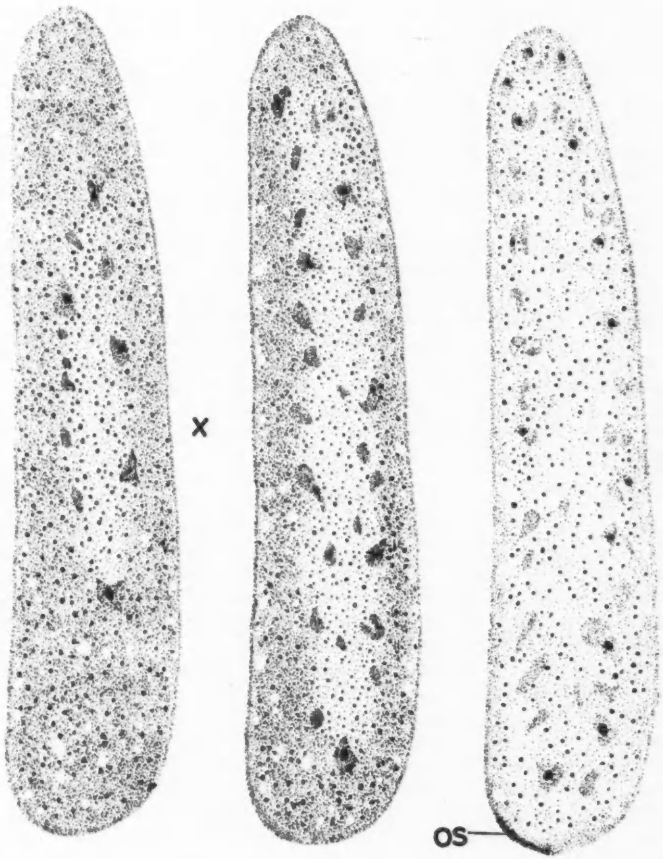


FIG. 7. Age 45–60 minutes. Thirty-two cell stage showing cell migration anteriorly. Reticulum within cell configuration greatly diminished.

FIG. 8. Age 60–75 minutes. Cells arranged at regular distances from egg center; nuclei displaced slightly peripherally in cells.

FIG. 9. Age 90–120 minutes. Cleavage cells more crowded in anterior pole; nuclei displaced peripherally. OS—Oosome.

MATURATION AND FERTILIZATION

Fertilization occurs in most insects after the egg membranes have formed. The sperm (polyspermy is the rule) from the spermatheca, enter the egg through one or more micropyles as the egg passes down the oviduct prior to oviposition. My attempts to determine the presence of sperm in any of the eggs studied proved fruitless. In over 50 prepared eggs from 1 to 15 minutes old, no trace of sperm was observed. In all probability the gametes fuse after about 5 to 10 minutes after deposition of the egg since in normal development, reduction division of the egg nucleus must occur before its subsequent union with the male gamete.

Immediately after deposition of the egg, the egg nucleus may be found first centrally, then dorso-laterally and finally fused with the periplasm in the anterior third of the egg. This area of fusion (Pl. I, fig. 2), slightly lateral to the dorsal surface contains the polar body. Indications are that only one polar body is formed from the maturation division. Although it is impossible to state with certainty, the lateral migration of the egg nucleus to the periplasm seems to be in a slightly posterior direction. After reduction division the female gamete migrates back towards the center of the egg, where fertilization probably occurs and begins to divide.

EARLY CLEAVAGE

Purely for purposes of convenience cleavage was arbitrarily divided into two separate stages. The first stage, early cleavage, deals with synchronous divisions, a condition where the daughter cleavage cells divide simultaneously or almost so. The second stage, late cleavage, deals with heterochronous divisions, a condition where the divisions of the daughter nuclei occur at different times.

Johannsen and Butt (1941) recognize the following types of cleavage in insects: (A) purely total—this type occurs among the Proctrotrupidae, Chalcidae and some others and is especially concerned with cases of polyembryony; (B) combination cleavage—this type involves total cleavage at first which later becomes superficial. Combination cleavage occurs in the group Collembola; (C) superficial—the majority of insects undergo this type of cleavage where the nucleus divides into daughter nuclei which by repeated divisions and migration invest the periplasm and establish the so-called blastoderm or primary epithelium. The eggs of *Lucilia sericata* fall into this category.

Following fertilization the fusion or cleavage nucleus is located in the anterior third of the egg. Here it divides into two daughter nuclei (Pl. I, fig. 3) which migrate both laterally and posteriorly. Each of these two cleavage nuclei is surrounded by cytoplasmic masses of almost equal size and are joined to each other by the egg reticulum which anastomoses throughout the entire egg. Thus the most distant portions of the egg have a distinct morphological association with the cleavage nuclei even though the latter have their specific loci in the anterior region. The second division produces four cells (Pl. II, fig. 4) which migrate posteriorly and in turn divide simultaneously into eight cells. (Pl. II, fig. 5). Lines enclosing the outer edges of these cells

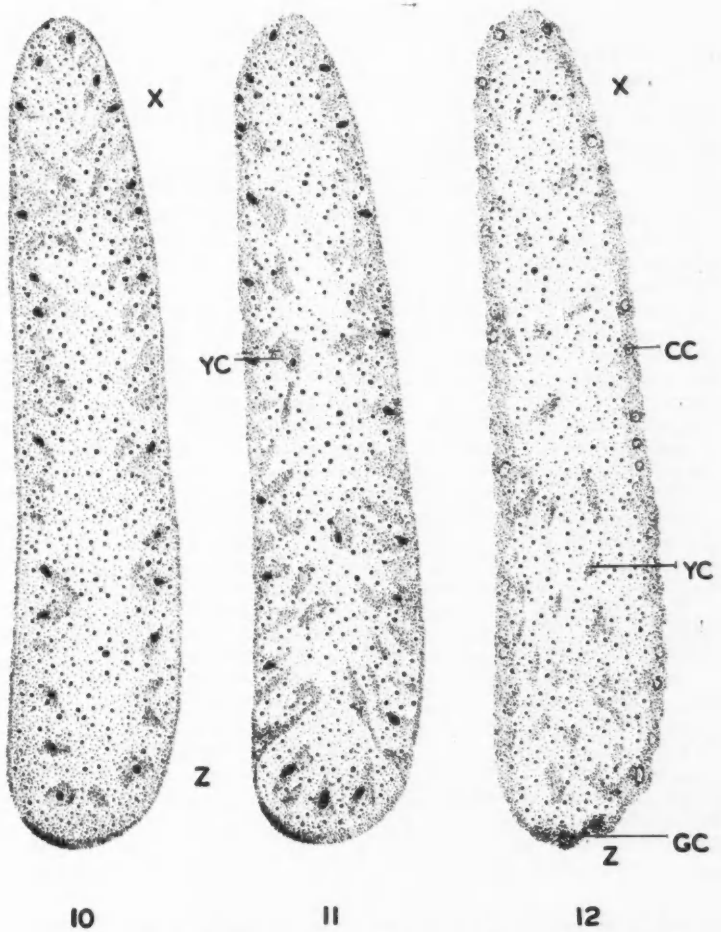


FIG. 10. Age 90–120 minutes. Cleavage nuclei penetrating periplasm in anterior third of egg. Primary yolk cells first appear in this region.

FIG. 11. Age 105–120 minutes. Periplasmic investment complete except for posterior polar region. Primary yolk cells now definite with their nuclei displaced medially. YC—yolk cell.

FIG. 12. Age 105–120 minutes. Cleavage cells complete their periplasmic fusion; nuclei appear vacuolate; oosome broken up and absorbed by cleavage cells, in posterior pole forming the germ cells. GC—germ cell.

would form a figure closely resembling the shape of the anterior half of the egg in which they are located. Sixteen cells (Pl. II, fig. 6) are formed from the next division which become arranged at almost regular distances from the center of the egg.

Probably the cessation of synchronous division occurs in the next division. In two preparations, I have observed a 20 and a 22 cell stage (Pl. V, fig. 15) with all the cells well separated from each other. Although these intermediate cell numbers may have been due to abnormal development I am of the opinion that the beginning of random division occurs during this stage of development. This opinion is augmented by the fact that synchronous divisions apparently do not occur after the 32 cell stage. (Pl. III, fig. 7). Probably the most significant phenomenon in this division is the migration of cells in three directions, anteriorly, posteriorly and laterally. Up to this point, migrations have been confined to the last two mentioned directions.

Concerning the ultimate causes for these simultaneous divisions and subsequent peripheral migration very little is known. Johannsen and Butt (1941) list two theories, that of Miller (1939) and that of Sehl (1931). Miller regards migration as passive drifting due to local changes in and near the cells with synchrony of division due to simultaneous nuclear influences. Sehl suggests that migration is due to the attraction of the periplasm upon the nuclei.

The central location of the cleavage cell nuclei during the first five divisions is fairly constant although their shape may vary considerably. The circular type is most common but variations ranging from the elongate to the tear-shapes are frequent. These tear or pear shaped nuclei may have their apices directed either centrally or peripherally.

The contour of the cleavage cells is very irregular and amoeboid. The irregular surface is due to indentation of the yolk globules surrounded on their margins by protoplasmic processes of the cleavage cells which merge with the reticulum. As no cell walls are present a true syncitium exists. Usually the more blunt portions of the cells face centrally. The reticulum enclosed by the cleavage cells appears only as narrow strands as compared to the rather heavy protoplasmic network lying between the cells and the cortical layer. This diminution of cytoplasm from the reticulum is in all probability associated with the formation of the nuclear cytoplasm of the cleavage which probably explains this reticular loss.

EXPLANATION OF PLATE V

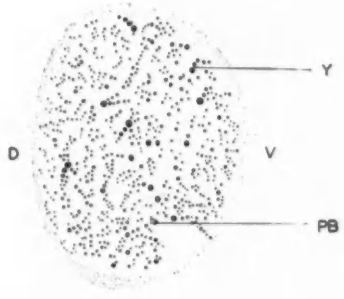
FIG. 13. Age 1–5 minutes. Transverse section approximately 130 microns from anterior pole showing polar body location. D—dorsal; PB—polar body; V—ventral; Y—yolk.

FIG. 14. Age 5–15 minutes. Transverse section at level of X, Pl. I, Fig. 2, showing the central location of a fusion nucleus. CN—cleavage nucleus; P—periplasm.

FIG. 15. Age 30–45 minutes. Transverse section through middle of a twenty-two cell embryo. CC—cleavage cell.

FIG. 16. Age 30–45 minutes. Transverse section at level of X, Pl. III, Fig. 7, of a thirty-two cell stage.

FIG. 17. Age 90–105 minutes. Transverse section at level of Z, Pl. IV, Fig. 10, showing horse-shoe shaped cleavage cells with their nuclei displaced peripherally.



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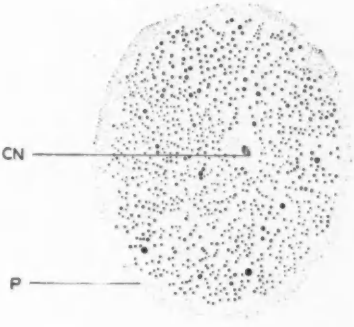

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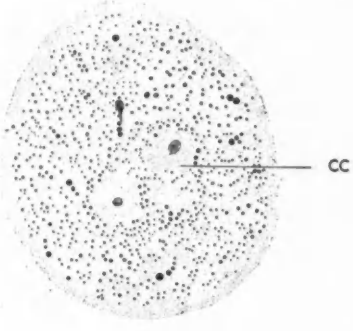

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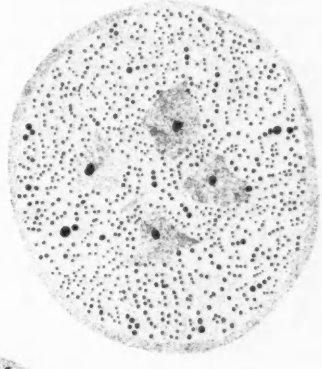

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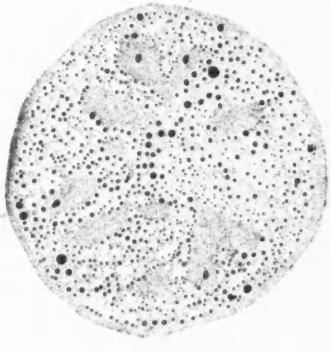

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LATE CLEAVAGE

Late cleavage involves (1) heterochronous cell division, (2) investment of the cleavage nuclei in the periplasm, (3) the formation of primary yolk cells, and (4) the beginnings of the primoridal germ cells. Following the establishment of the 32-cell stage the cleavage cells undergo several divisions prior to their peripheral investment. Judging from the total number of cells from consecutive age groups the number of consecutive divisions is three. Each division and migration of cells increases the dimensions of the "hollow figure" of cells which is slightly displaced and concentrated towards the anterior pole. Thus the cells are brought closer and closer to the periplasm until fusion finally occurs. (Pl. IV, fig. 10; Pl. VI, fig. 18).

Both the time and place of cleavage cell penetration into the periplasm vary in different groups of insects. In some they reach the surface simultaneously and in others at some particular position in the egg such as the anterior or posterior pole on the ventral surface. In *Lucilia sericata* the region of initial investment is located near the anterior pole in about the same horizontal plane as the original cleavage nucleus. This fusion apparently occurs dorsally, ventrally and laterally at the same time. From this initial area fusion occurs both anteriorly and posteriorly until the cleavage cells finally reach the posterior pole. The outer surface of the egg in section now appears irregular because of the outward "pressure" of migrating cleavage cells on the periplasm. (Pl. IV, fig. 12; Pl. VI, fig. 19).

The cell nucleus, immediately prior to the fusion of the cleavage cells with the periplasm, no longer occupies a central position but is now located towards its outer margin. After about the second division following the 32-cell stage the cleavage cells become horse-shoe shaped with a nucleus in each arm of the shoe. (Pl. IV, figs. 10, 11; Pl. V, fig. 17). These binucleate cells then divide producing two elongate triangular cells (Pl. VI, fig. 18), which penetrate the periplasm, blunt edge leading.

Yolk cells are classified as to their time and place of origin. The primary yolk cells are those which do not reach the periphery but remain behind in the yolk. The secondary yolk cells are those which migrate back into the yolk during the formation of the blastoderm. We are concerned here with the origin of the former. Both in sagittal (Pl. IV, figs. 11, 12) and transverse sections (Pl. VI, fig. 19) large amoeboid cells can be seen near the cleavage cells that have penetrated the periplasm. These cells, the primary yolk cells, are identical to cleavage cells with the exception that their nuclei are medial and that unlike true cleavage cells they do not enter the periplasm but return into the yolk. In *Lucilia sericata* they are rather numerous.

Since this paper is concerned chiefly with cleavage, only the briefest mention will be made of the origin of germ cells. They would have been excluded entirely except for the fact that they arise from formative protoplasmic investment. As already mentioned the dorsal surface of the periplasm of the posterior pole contains the oosome. Several cleavage cells penetrate this region, break up and absorb this inclusion and form very dark circular masses (Pl. IV, fig. 12; Pl. VI, fig. 22),

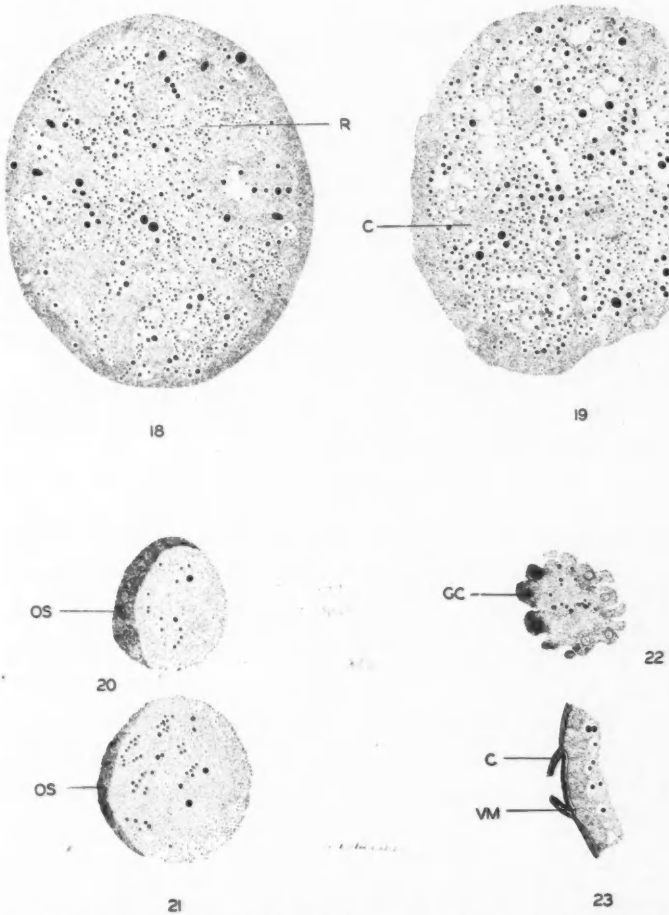

FIG. 18. Same egg as in Fig. 17 at level of X, showing fusion of the cleavage nuclei with periplasm. R—reticulum.

FIG. 19. Age 105–120 minutes. Transverse section at level of X, Pl. IV, Fig. 12, showing cleavage nuclei in periplasm; five yolk cells are shown.

FIG. 20. Age 30–45 minutes. Transverse section about 10 microns from posterior pole showing oosome on dorsal surface. OS—oosome.

FIG. 21. Same egg as in Fig. 20, 15 microns from posterior pole. OS—oosome.

FIG. 22. Age 105–120 minutes. Transverse section at level Z, Pl. IV, Fig. 12 showing 4 germ cells protruding from dorsal surface. GC—germ cell.

FIG. 23. Age 1–5 minutes. Transverse section of dorsal surface through chorionic folds (see text fig.) showing membrane-egg relationship. C—chorion; VM—vitelline membrane.

which slightly protrude from the polar surface. These cell masses are the anlage of the primordial germ cells.

SUMMARY

1. The time required for egg development up to the formation of the germ cells is about 2 hours.

2. Probably only a single polar body is formed which lies close to the dorso-lateral surface of the anterior third of the egg. Fertilization probably occurs immediately after maturation.

3. There are 8 or 9 cell divisions prior to peripheral investment; the first five are synchronous or almost so, the others occurring at random.

4. Cleavage cells first attain the periphery in the anterior third of the egg at about the same horizontal plane as the original egg nucleus.

5. Primary yolk cells are formed from cleavage cells which have migrated almost to the periplasm and have returned into the yolk.

6. The egg is of the determinate type; the cleavage cells reach the posterior pole last where they enter into and absorb the oosome forming the anlage of the primordial germ cells.

BIBLIOGRAPHY

Auten, M. 1934. The early embryological development of *Phormia regina:* Diptera (Calliphoridae). Ann. Ent. Soc. Amer., 27 (3): 481–506. 41 Figs., 7 Pls.

Butt, F. H. 1934. Embryology of *Sciara:* Sciaridae (Diptera). Ann. Ent. Soc. Amer., 27 (4): 565–579. 18 Text figs., 13 Figs., 2 Pls.

Gambrell, Mrs. F. L. 1933. The embryology of the black fly, *Simulium pictipes* Hagen. Ann. Ent. Soc. Amer., 26 (4): 641–671. 45 Figs., 12 Pls.

Johannsen, O. A., and **Butt, F. H.** 1941. Embryology of insects and myriapods. First Edition. McGraw-Hill Book Co.

Kennedy, C. H. 1932. Methods for the study of the internal anatomy of insects. Columbus, Ohio. 103 pages.

Kingsbury, B. F., and **Johannsen, O. A.** 1927. Histological technique. John Wiley and Sons, Inc., New York.

Lee, A. B. 1937. The microtomists vade-mecum. Tenth Edition. Blakiston and Son, Inc.

Nelson, J. A. 1915. Embryology of the honey bee. Princeton. 282 pages, 95 Figs., 6 Pls.

NORTH AMERICAN DICTYNID SPIDERS: THE BENNETTI GROUP OF AMAUROBIUS

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This group of spiders, here designated as the *bennetti* group of *Amaurobius*, comprises those North American species which group around *Amaurobius bennetti* (Blackwall). In these species, the epigynum has a pair of large lateral lobes which converge posteriorly around a small ovoid median lobe. The male has three distinct spurs on the tibia of the palpus, at the distal end above. The more detailed characteristics of this group are as follows:

Color: Carapace yellowish to reddish brown, usually with the front and sides of head darkened, at least in the female. Chelicerae reddish brown to dark brownish black. Labium and endites yellowish to dark chestnut brown, with narrow whitish tips; sometimes shaded with dusky in the male. Sternum yellowish to reddish brown, sometimes shaded with dusky. Legs yellowish to sometimes shaded with dusky, especially in certain males. Palpi same color as legs proximally, but darker distally. Abdomen typically dark gray with a light gray pattern above, more or less as shown in figures 6 and 8. Venter faded, or more often marked with four longitudinal lines or bands of pale gray. Sometimes the abdomen is uniform gray or black, or nearly so. Spinnerets yellowish to dusky brown. Epigynum reddish brown.

Structure: These species are uniformly robust in general structure. They vary in length from about 8 mm. to more than 15 mm.

Female: Carapace, in outline, longer than wide, the ratio about 10:7; the posterior end is broadly and shallowly emarginate; the sides sub-parallel, being slightly convexly rounded; head wide, being about two-thirds the width of the thorax, the length of the head beyond the cervical indentations about half its width; cervical indentations moderate; head essentially "square" in front. In profile, the ventral line of the carapace is nearly straight, sometimes slightly undulate, with the posterior end rising slightly, and with a slight downward dip at the cervical indentation, in front of which it rises sharply to the margin of the clypeus; clypeus low, about vertical, one to two diameters of an anterior median eye in height; anterior eyes slightly protruding, above which the profile rises steeply through the posterior eyes, then becomes nearly level to the median furrow, being slightly convex along the top of the head and highest near the middle of the head; posterior declivity of moderate gradient, and occupying about two-fifths of the length of the carapace. The median depression is a short, deep, narrow groove. Eyes 8, in two rows; subequal, usually the a. s. eyes are largest and the p. m. eyes smallest. Eye area occupies about half the width of the head. Anterior eye row straight to slightly procurved; median eyes a radius, plus or minus, apart, one to two diameters from the side eyes. Posterior row slightly procurved, sometimes nearly straight; median eyes 1.5 to 2.5 diameters apart, 2.5 to 4.0 diameters from the side eyes.

The two lateral eyes on each side about a radius apart. Median ocular quadrangle wider behind than in front, about as long as the width behind.

Chelicerae stout, vertical, parallel; the exposed length is a little less than the width of both of them in front; they are subcontiguous for most of their length; ectal outlines, as seen from in front, nearly straight and parallel. As seen from the side, the anterior base of the chelicerae is strongly convex to strongly geniculate. Boss prominent, smoothly rounded. With a sharp ridge along the mesal corner behind. Fang groove with 4 or 5 teeth on the anterior margin, of which the next to the mesal tooth is the largest; with 3 or 4 teeth on the posterior margin, of which the mesal tooth is the largest. Fang short, stout, simple.

Sternum moderately small, ovoid, slightly truncate in front; sides rounded or undulate; widest at second coxae; pointed behind, barely separating hind coxae. Labium longer than wide; basal corners prominently excised; tip broadly emarginate. Endites stout, elongate, extending well beyond the labium; subparallel; slightly expanded distally; the antero-mesal corners slightly convergent, but not touching. Palpus moderately small and slender; normal; extending to about the distal end of patella 1; femur, tibia-patella, and tarsus all about equal in length; terminal claw prominent, toothed.

Legs essentially homogeneous, robust, without special modifications; 1 4 2 3 or 4 1 2 3 in order of length, but the size differences are not great; gradually tapering to distal end; spined. Calamistrum double, extending for about half the length of the metatarsus; metatarsus 4 is flattened on top above the calamistrum, and bears a thick growth of short, uniform hairs on the flattened part. Legs with a row of fine trichobothria on tarsi and metatarsi. The arrangement of the spines is shown by figure 5.

Abdomen simple, ovoid, widest near middle, more or less flattened on top; width about 0.6 of length, wider than high. Spinnerets 6, short, convergent at tips; anterior pair stoutest, about same length as posterior pair. Cribellum divided. The epigynum consists, superficially, of three lobes—a pair of large lateral lobes, which surround the small ovoid median lobe and come together posteriorly, where they are contiguous or nearly so. Ectad of each lateral lobe, on the posterior margin, is an excavation, with the anterior rim more or less chitinized. This excavation is commonly filled with solid extraneous material. On the posterior face of the epigynum (hidden in the furrow) is a small median sclerite. The openings are concealed between the lateral and median lobes; the large spermathecum is contained in the lateral lobe.

Male: Compared to the female, the male exhibits the following differences: Carapace with the head narrower and shorter, width only little more than half that of the thorax; median depression larger; posterior declivity occupying only about a fourth of the length. Eyes closer together, the distances between them approaching the minimum distances given for the female. Chelicerae not so robust. Legs longer and often more slender in proportion to length; spines more numerous, with fewer reductions on legs 1 and 2. The calamistrum is much reduced, or nearly absent, as is also the flattened area on the dorsal side

of the metatarsus with its covering of short hairs. Abdomen much smaller. Palpus moderately stout. Femur and patella not modified. Tibia short and stout, broadened anteriorly, with three conspicuous spurs visible from the dorsal aspect, these directed in general distad. Tarsus moderately small and short; cymbium somewhat triangular. The palpal organs are compact; there are three separate sclerites—a subtegulum; a tegulum, to which the short stout embolus is fused; and a well developed median apophysis. A membranous lamella arises from the center of the tegulum, distally. Structure of the palpal organs show but slight variation in the different species.

Setae: Aside from the movable spines on the legs and palpi, the entire body is covered with large slender bristles, with a more dense underlying cover of short fine hairs. At no place is the covering sufficiently dense as to conceal the integument. There are no well-developed scopulae, except the brush at the meso-distal end of the endites. There is a fringe of coarse hairs anterior to the fang on the chelicerae. The setae on the tarsi of the legs form a dense short covering, especially on the under side; but these are not formed into scopulae.

Phylogeny: While there is some doubt as to the phylogenetic relationships of some of the species, especially those for which adults or males are not known, figure 1 indicates a scheme of the approximate phylogeny within this group.

Procedure: The species are listed alphabetically, regardless of their relationships. The descriptions contain only a few of the more essential characters and omit much that is common to all the species. The localities are listed in units of one degree longitude by one degree latitude; the co-ordinates of the southeast corner of the quadrangle are given, longitude first, separated from the latitude by a period. The records are based mostly on published reports and the material in the University of Utah Collection. Some of the material from the American Museum of Natural History is also recorded, including the types of eight of the new species. This latter material was made available through the generous co-operation of Dr. Willis J. Gertsch.

KEY TO SPECIES

The North American species may be separated by means of the following key, with certain reservations. Some of the species are not represented by adults of one or both sexes and have had to be omitted. The spines are used extensively in the females, as they show considerable variation, and constitute definite, concise characters. But the spines are frequently erratic within a species, and often the two sides of the same individual are not the same. While each species has a typical arrangement, a number of individual exceptions occur. This key attempts to include the more common exceptions, where known, but cannot include all the rare cases. Nevertheless, it should be fairly reliable in tracing down the species included herein.

1. Females[1] 2
   Males[2] 12

[1]The females of *alaskanus*, *angelus*, and *pallescens* are omitted from this key, since they are unknown to us.

[2]The males of the following species are unknown or not at hand, and are not included in this key: *arizonicus*, *catalinus*, *kamelus*, *melanus*, *nomeus*, *pallescens*, *severinus*, *shastus*, and *subnomeus*.

2. Metatarsus 1 with only one ventral spine at distal end (three spines visible at distal end from below) 3
   Metatarsus 1 with two ventral spines at distal end (four spines visible at distal end from below) 11
3. Metatarsus 1 with only two spines near the base as seen from below 4
   Metatarsus 1 with 3 or 4 spines near base visible from below 9
4. Patella 3 with a spine on the anterior side 5
   Patella 3 without a spine on the anterior side 7
5. Anterior median eyes slightly larger than the posterior median eyes ..... **pictus**
   Anterior median eyes slightly smaller than the posterior median eyes 6
6. Epigynum with a conspicuous raised ridge, extending anteriorly along the mesal edge of each lobe; posterior ectal corner not angulate (see fig. 21) ..... **kamelus**
   Epigynum without such a ridge; posterior ectal corner angulate as seen from ventral view (see fig. 19) ..... **tamarus**
7. Femur 3 with a small median spine at distal end above 8
   Femur 3 without a median distal spine ..... **nomeus**
8. Abdomen dense black ..... **melanus**
   Abdomen gray, with a dorsal pattern of pale gray ..... **subnomeus**
9. Middle lobe of epigynum about half as wide as a lateral lobe; eastern North America ..... **bennetti**
   Middle lobe of epigynum distinctly less than half the width of a lateral lobe; western North America 10
10. Length more than 12 mm ..... **nevadensis**
    Length less than 12 mm ..... **tamarus**
11. Metatarsus 1 with only two spines near base as seen from below 12
    Metatarsus 1 with three or four spines near base as seen from below 17
12. Epigynum with posterior median sclerite (hidden in furrow) very small and inconspicuous ..... **severinus**
    Epigynum with posterior median sclerite large and conspicuous, triangular or pentagonal 13
13. Epigynum with the middle lobe (as seen from ventral view) nearly as wide as long 14
    Epigynum with middle lobe decidedly longer than wide, usually twice as long 15
14. Dorsal pattern of abdomen conspicuous ..... **arizonicus**
    Dorsal pattern of abdomen obscure ..... **olympus**
15. Epigynum with a secondary lobe ectad of the main lateral lobe and separated from it by a deep notch ..... **deces**
    Epigynum without a secondary lateral lobe 16
16. Anterior median eyes nearly a diameter apart ..... **catalinus**
    Anterior median eyes only a radius or slightly more apart ..... **shastus**
17. Length more than twelve millimeters 18
    Length less than twelve millimeters 19
18. Posterior face of epigynum (which is hidden in the furrow) with the ectal part broadly excavated, and with the median sclerite very small and inconspicuous ..... **severus**
    Posterior face of epigynum with the ectal part not broadly excavated, and with the median sclerite large and sub-triangular ..... **nevadensis**
19. Patella 3 with a spine on the anterior side ..... **canada**
    Patella 3 without an anterior spine 20
20. Anterior median eyes slightly larger than the posterior median eyes; epigynum broadly excavated behind ..... **severinus**
    Anterior median eyes not larger than the posterior median eyes; epigynum not broadly excavated behind ..... **enus**
21. Tibia of palpus with the mesal spur shorter than the middle spur ..... **pictus**
    Mesal spur longer than the middle spur 22
22. Mesal spur less than twice as long as the middle spur ..... **tamarus**
    Mesal spur at least twice as long as the middle spur 23
23. Sides of head conspicuously reticulated with dusky 24
    Sides of head not reticulated with dusky 28
24. Palpus with mesal spur of tibia straight distally for most of its length 25
    Palpus with mesal spur of tibia more or less curved distally 27

25. Middle spur of tibia obliquely truncate at distal end.....**deces**
Middle spur of tibia more or less conical in shape.....26
26. Tibia of palpus with the middle spur more rounded at tip; mesal spur with a more conspicuous double curve along the mesal edge; eastern North America (See fig. 13).....**bennetti**
Tibia of palpus with the middle spur more acute at tip; mesal spur with the mesal edge nearly straight; western North America (See fig. 14).....**enus**
27. Palpus with mesal spur of tibia tapering to a needle-like point.....**canada**
Palpus with the mesal spur of the tibia remaining relatively uniform in thickness to near the tip, then coming to a point quickly.....**tacoma**
28. Tibia of palpus with the distance from the bottom of the notch between the middle and mesal spurs to the tip of the mesal spur much greater than the distance from the tip of the middle spur to the base of the tibia.....29
Tibia of palpus with these distances about equal or the latter greater.....30
29. Tibia of palpus with the middle lobe short and situated on the base of the mesal spur.....**angelus**
Tibia of palpus with the middle lobe large and distinctly separated from the mesal spur.....**olympus**
30. Tibia of palpus with the middle spur double; mesal spur short, slender, and curved near tip.....**alaskanus**
Tibia of palpus with middle spur single; mesal spur stout at base and tapering to a sharp, nearly straight tip.....31
31. Middle spur of tibia of palpus simple, distal end rounded; mesal spur bent toward a line extended from the median point of the patella through the tip of the middle spur of the tibia.....**nevadensis**
Middle spur of tibia of palpus obliquely truncate or with the distal margin concave; mesal spur not bent toward a line extended from the median point of the patella through the tip of the middle spur of the tibia...**severus**

Amaurobius alaskanus new species

Figure 31

Badly damaged male.

Color: Probably about typical. Legs lightly annulated. Front of head and chelicerae dark reddish brown. (Abdomen missing from type).

Structure: Posterior eye row procurved. Posterior median eyes a little more than 2 diameters apart, nearly 3 diameters from the side eyes. Tibia of palpus distinctive. The middle lobe is split into two distinct small lobes. Mesal lobe short, with distal half slender and of about uniform thickness, strongly curved.

Carapace 3.85 mm. long, 3.25 mm. wide.

Type locality: "Alaska" (no further data). ♂ Holotype in collection of the American Museum of Natural History.

Amaurobius angelus new species

Figure 29

Male.

Color: Carapace orange brown; head slightly reticulated on the sides. Chelicerae dark reddish brown. Labium and endites reddish brown. Sternum, legs and palpi light brownish yellow. Abdomen gray; the dorsal pattern obscure.

Structure: Evidently related to *olympus*. The palpus has a similar long mesal process on the tibia, but the middle lobe is located on the base of the mesal process, instead of appearing as a distinct lobe.

Measurements: ♂ Holotype.

	♂ Holotype	
	Mm.	*Ratio*
Length	9.60	200
Carapace:		
Length	4.80	100
Width	3.47	72
Tibia-patella:		
1	5.20	108
4	4.93	103

Type locality: Quadrangle W. 118° : N. 34°, "Los Angeles, California" (no further data). ♂ holotype in Collection of American Museum of Natural History.

Amaurobius arizonicus new species

Figure 33

Female.

Color: Carapace light brown, darker on the head. Chelicerae dark chestnut brown. Labium and endites reddish brown. Legs and palpi light brownish yellow, the palpi reddish brown distally. Abdomen gray, with a distinct light gray pattern on dorsum.

Structure essentially typical, with minor distinctions in the epigynum and spines. The posterior face of the epigynum is excavated ectally; the median lobe is much longer than wide; the lateral lobe bears a small raised angle at distal end. Eye rows slightly procurved. The a. m. eyes are about 0.7 diameters apart, 1.8 diameters from the side eyes. The p. m. eyes are nearly 2.0 diameters apart, about 3.0 diameters from the side eyes. The more significant spine variations are these:

Tibia 1 with one or two spines on anterior face.
Metatarsus 1 with two ventral spines at distal end; with only two spines near base.
Patella 3 without an anterior spine. (One exception noted.)
Femur 3 without a median distal spine. (One exception noted.)
Metatarsus 4 without a median spine near base. (One exception noted.)

Measurements:

	♀ 1	♀ 2	♀ 3	*Average*	*Ratio*
Length	12.30	11.00	16.00	13.10	250
Carapace:					
Length	4.80	4.53	6.40	5.24	100
Width	3.20	3.07	4.26	3.51	67
Tibia-patella:					
1	4.07	4.60	6.40	5.36	102
4	4.96	4.40	6.40	5.25	100

Type locality: Quadrangle W. 109° : N. 33°, Arizona. 17 miles N. E. Whiteriver, White Mountains; July 8–10, 1940; ♀ holotype, 4 ♀ paratypes; Gertsch and Hook collectors. Two ♀ paratypes in University of Utah Collection; others in American Museum.

Other Locality: Quadrangle W. 109° : N. 32°, Arizona. Graham Mt.; Sept. 10, 1937; ♀ paratype; Owen Bryant. (American Museum.)

Amaurobius bennetti (Blackwall)

Figures 13, 22

Ciniflo bennetti Blackwell, 1846, *Ann. & Mag. Nat. Hist.*, 17: 41.
Amaurobius sylvestris Emerton, 1888, *Trans. Conn. Acad. Sci.*, 7: 451; *10: 1.
Amaurobius sylvestris Banks, 1892, *Proc. Acad. Phila.*, 29.
A. bennetti Banks, 1895, *Journ. New York Ent. Soc.*, 3: 82.
A. sylvestris Emerton, 1902, Common Spiders, 213; *489–490.
A sylvestris Simon, 1903, *Bull. Mus. Paris*, 9: 386.
A. bennetti Banks, 1910, *Bull. U. S. Nat. Mus.*, No. 72: 18.
A bennetti Petrunkevitch, 1911, Cat. Spid. Amer., 104.
A bennetti Comstock, 1912, Spider Book, 277; *255–257.
A bennetti Emerton, 1919, *Trans. Royal Canadian Inst.*, 12: 324.
A bennetti Kaston, 1938, *Conn. Geol. & Nat. Hist. Surv.*, Bull. 60: 181.
A bennetti Truman, 1942, *Proc. Penn. Acad. Sci.*, 16: 27.

Color: Essentially typical, with minor modifications. Carapace of male has more or less distinct radial streaks and the sides of the head are reticulated. Sternum darkened, dusky brown in the male. Abdomen with the spots of the dorsal pattern usually coalesced into one large complex mark; the sides usually speckled with light gray; the venter usually marked with longitudinal bands of light gray, rather than merely faded.

Structure: Size medium to small for this group. Legs only moderately robust. Eye rows slightly procurved. Anterior median eyes of female about a radius apart, 1.50 to 1.75 diameters from the side eyes. Posterior median eyes about 2 diameters apart, 3.5 to 4.0 diameters from the side eyes. Eyes of male closer together. Median ocular quadrangle about as wide behind as long. Epigynum typical; posterior ectal corners rounded. Male palpus with the mesal spur of the tibia long and pointed, the middle spur rounded at tip, and the ectal spur with the pointed tip bent sharply mesad. The spines on the legs of the female show the following variations:

Tibia 1 with one to three spines on anterior face.
Metatarsus 1 with one distal ventral spine, and with lateral spines near base on one or both sides.
Femur 3 without a median distal spine.
Patella 3 with or without an anterior spine.
Metatarsus 4 without a dorsal median spine near base, except rarely.

Measurements:

	♂		♀	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	8.60	181	10.00	222
Carapace:				
Length	4.75	100	4.50	100
Width	3.45	73	3.07	68
Tibia-patella:				
1	5.20	109	3.95	88
4	5.10	107	3.80	84

Type locality: About W. 79° 28′ : N. 43° 40′, Ontario, near Toronto; 1840; Potter. (After Emerton, 1919.)

Known localities: Newfoundland. (Emerton, 1919). 62.49, Island

Anticosti. (Petrunkevitch, 1911). 63.42, 4♀, Nova Scotia: Truro. Nova Scotia. (Emerton, 1919). 70.43, ♀, Maine: N. W. Wells; August 12, 1933; Wilton Ivie. 71.46, Quebec: Quebec. (Emerton, 1919). 71.44, New Hampshire: White Mts. (Emerton, 1888). 71.42, ♂, Massachusetts: Blue Hills. (72.41), Connecticut. (Kaston, 1938). New England: "All over." (Emerton, 1888). 73.41, ♀, Connecticut: Norwalk; July 2, 1933; W. Ivie. 74.42, ♂, New York: Mt. Garfield. 74.41, 3♀, New York: Sterlington. 76.42, New York: vicinity Ithaca. (Banks, 1892). 76.42, 2♀, New York: Ithaca. 77.42, 4♀, New York: Wallace; June 19, 1933; W. Ivie. 79.43, Types, Ontario: Toronto; 1940; Potter. Type locality. 79.40, Pennsylvania: Presque Island. (Truman, 1942). 80.46, ♀s, Ontario: Island 1024, Lake Temagami; Aug. 15–25, 1946; Gertsch, Ivie, and Kurata. 82.41, ♀, Ohio: Put-in-Bay, Lake Erie; Aug. 16, 1935; W. Ivie. 82.39, 2♀, Ohio Cantwell Cliffs; July 27, 1935; Barrows and Ivie. 82.36, ♀, Tennessee: Erwin; July 8, 1933; Wilton Ivie. 83.35, ♀, Tennessee: Little Pigeon Cr.; July 9, 1933; W. Ivie. 86.38, ♀, Indiana: Smith Woods, N. E. Springville; Oct. 13, 1940; W. J. Beecher. 87.39, ♀, Indiana: Annapolis; Oct. 21, 1940; R. L. Wetzel. 90.46, Im., Wisconsin: Kimball; July 2, 1910; R. V. Chamberlin. 93.42, ♀, Iowa: Mongoina to Boone; June 23, 1910; R. V. Chamberlin. 94.49, Ontario: Minaki. (Emerton, 1919). 96.50, Manitoba: Lake Winnipeg. (Emerton, 1919).

Amaurobius canada new species

Figures 28, 34

Color: Carapace light brown, female with front of head darker, male with head reticulated and with thorax marked with three pairs of dusky wedges. Chelicerae reddish brown in male, dark chestnut in female. Labium and endites dark reddish brown, with narrow whitish tips, in female; light brown shaded with dusky in male. Sternum orange brown in female, dusky brown in male. Abdomen gray, with dorsal pattern moderately distinct in female; darker, with dorsal markings obscure, in male.

Structure essentially typical. Evidently near to *deces* and *enus*. Male: Eye rows faintly procurved. A. m. eyes 0.8 diameter apart, 1.8 diameters from the side eyes. P. M. eyes 1.8 diameters apart, 2.3 diameters from the side eyes. Palpus very similar to those of *enus* and *bennetti*, but the ectal edge of the mesal process is more curved.

Female: Anterior median eyes 0.9 diameter apart, 2.5 to 3.0 diameters from the side eyes. Epigynum with the middle lobe about as wide as long; lateral lobes with a tiny secondary lobe on ectal side at base. Spines of legs modified as follows:

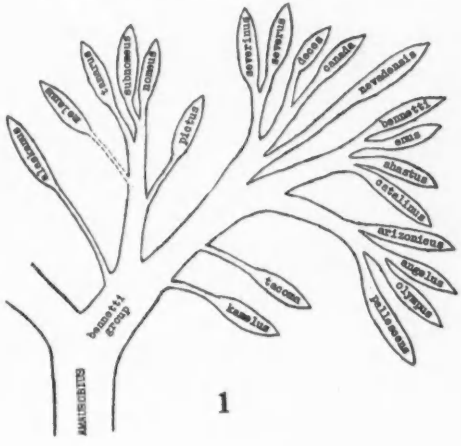
Tibia 1 with 3 spines on anterior face.

Metatarsus 1 with two ventral spines at distal end, and with one or two lateral spines near base, besides the two ventral spines.

Patella 3 with an anterior spine.

Femur 3 with a distal median spine.

Metatarsus 4 with a median spine near base above.



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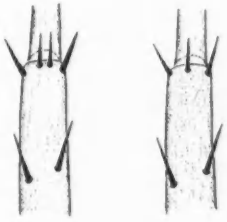

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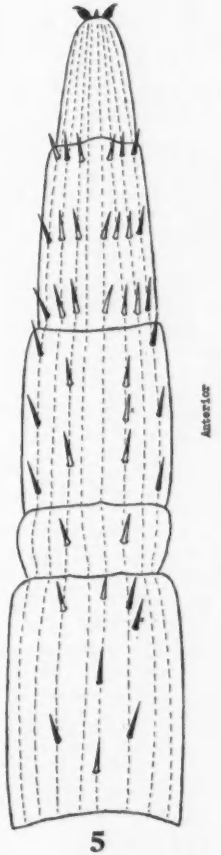


5

Usually on all legs of all species

Usually on leg 3 of all species; often absent from other legs

Present in some species, absent in others

Present only on leg 1, or occasionally on leg 2

1. Diagram of the probable phylogeny of the *bennetti* group of *Amaurobius*. 2. *Amaurobius*, eyes of female. 3. Metatarsus, showing two distal ventral spines. 4. Same, showing one distal ventral spine. 5. Diagram showing the spines on the legs of *Amaurobius*, depicted as though the integument were split along the mid-ventral line and laid open. (Explanation of spine symbols below figure.)

Measurements:

	♂ Holotype		♀ Allotype	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	9.60	200	12.00	214
Carapace:				
Length	4.80	100	5.60	100
Width	3.25	68	3.73	67
Tibia-patella:				
1	5.35	111	5.23	93
4	5.35	111	5.06	90

Type locality: Quadrangle W. 119° : N. 50°, British Columbia: Salmon Arms; ♂ holotype, ♀ and immature paratypes, May, 1940; ♀ allotype, May, 1941; ♂ paratype, October, 1939; Olive R. Leech collector. ♂ ♀ paratypes in University of Utah, others in American Museum.

Other localities: 122.45, ♀, Oregon: Multnomah Falls; July 4, 1942; Borys Malkin. (American Museum). 121.44, ♀, Oregon: Warm Springs; July 7, 1944; Roger Teel. (American Museum).

Amaurobius catalinus new species

Figure 35

Color: Carapace brown, darker on the head. Chelicerae dark chestnut brown. Labium and endites dark reddish brown. Sternum yellowish brown, lightly shaded with dusky. Legs and palpi yellowish brown, with the tibia and tarsus of palpus reddish brown. Abdomen dark gray, with a conspicuous pattern of pale gray above. Spinnerets and epigynum orange brown.

Structure: Size medium to large for this group. Posterior eye row straight or slightly procurved. A. m. eyes 0.8 diameter apart, 1.7 diameters from the side eyes. P. m. eyes 1.8 diameters apart, 2.8 diameters from side eyes. Epigynum simple, rounded; without secondary lobes or processes; middle lobe nearly as wide as long. Spines of legs modified as follows:

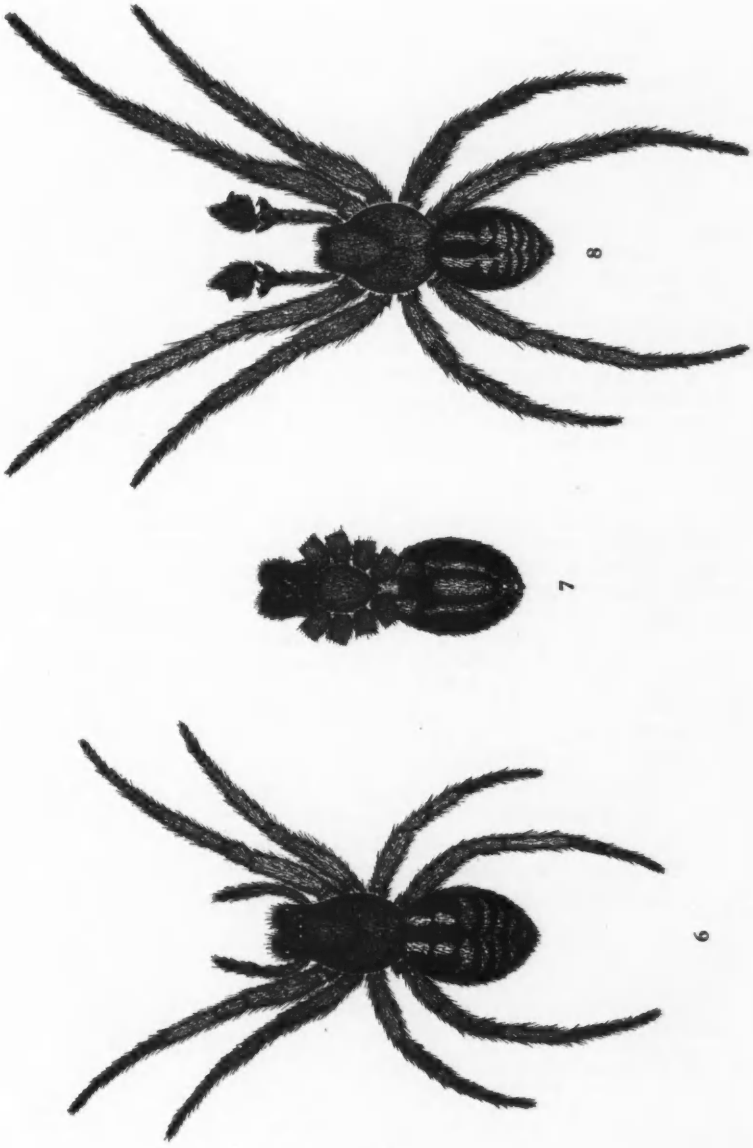
Femur 1 lacking distal spine on posterior side.
Tibia 1 with one or two spines on anterior face.
Metatarsus 1 with two ventral spines at distal end, and without lateral spines near base.
Patella 3 usually without an anterior spine.
Metatarsus 4 without a median dorsal spine at base.

Measurements:

	♀ 1	♀ 2	♀ 3	*Average*	*Ratio*
Length	10.00	11.00	10.80	10.60	203
Carapace:					
Length	5.05	5.10	5.47	5.21	100
Width	3.34	3.47	3.63	3.46	66
Tibia-patella:					
1	4.43	4.55	4.88	4.62	89
4	4.60	4.60	4.88	4.69	90

EXPLANATION OF PLATE II

6. *Amaurobius tamarus* new species, female. 7. Same, ventral view of body of female. 8. Same, male.



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Type locality: Quadrangle W. 110° : N. 32°. Arizona: Soldiers Camp, Bear Wallow Station, Catalina Mts.; ♀ holotype, 2 ♀ paratypes. One ♀ paratype in University of Utah Collection, the others in the American Museum Collection.

Amaurobius deces new species

Figures 24, 30

Color: ♀ Carapace orange brown, darker on the head. Chelicerae dark chestnut brown. Labium and endites dark reddish brown, with narrow whitish tips. Sternum light brown, lightly shaded with dusky. Legs yellowish brown. Abdomen dark gray, with dorsal pattern usually distinct, usually made up of separate spots; venter mostly dark gray, with the light gray forming into four more or less distinct longitudinal lines or bands.

♂. Carapace light brown, with sides of head and thorax reticulated with dusky, and with dusky radial streaks. Chelicerae reddish brown. Labium and endites dusky brown. Sternum dark dusky brown. Legs and palpi light brown, shaded with dusky. Abdomen as in female, but averages darker.

Structure: ♂. Eye rows procurved. A. m. eyes 1.0 diameter apart, 1.5 diameter from the side eyes. P. m. eyes about 2.0 diameters apart, about 3.0 diameters from the side eyes. Structure otherwise typical, except for minor differences in the tibia of the palpus. The mesal process of the palpus is straight and sharp pointed; the middle lobe is broad and obliquely truncate.

♀. Anterior median eyes about 0.8 diameter apart, 1.7 diameters from the side eyes. Posterior median eyes about 2.0 diameters apart, or slightly less, about 3.6 diameters from the side eyes. Epigynum with a distinct lobe on the rim ectad of the lateral lobes. The spines on the legs show the following more significant variations:

Tibia 1 with 1, 2, or 3 spines on the anterior face, usually 2.

Metatarsus 1 with two ventral spines at distal end, without lateral spines near base.

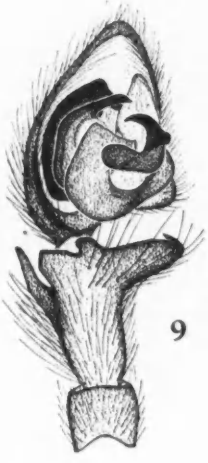
Femur 3 usually with a distal median spine.

Patella 3 usually without an anterior spine.

Metatarsus 4 usually without a median dorsal spine near base.

EXPLANATION OF PLATE III

9. *Amaurobius tamarus* n. sp., ventral view of male palpus. 10. Same, dorsal view of tibia of palpus. 11. *Amaurobius nomeus* Chamberlin, dorsal view of tibia of palpus. (After Chamberlin.) 12. *Amaurobius pictus* Simon, dorsal view of tibia of palpus. 13. *Amaurobius bennetti* (Blackwall), dorsal view of tibia of palpus. 14. *Amaurobius enus* n. sp., dorsal view of tibia of palpus. 15. *Amaurobius olympus* n. sp., dorsal view of tibia of palpus. 16. *Amaurobius nevadensis* Simon, dorsal view of tibia of palpus. 17. *Amaurobius severus* Simon, dorsal view of tibia of palpus.



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Measurements:

	♂		♀s (5)	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	8.00	188	9.46	200
Carapace:				
Length	4.26	100	4.72	100
Width	3.07	72	3.13	66
Tibia-patella:				
1	4.42	104	4.05	86
4	4.32	101	4.04	86

Type locality: W. 123° 2′ : N. 44° 10′. Oregon: Coburg Hills, 3 miles N. E. Coburg; March 22, 1942; Borys Malkin and Harold Stobie; ♂ holotype, ♀ allotype, 2♂ 5♀ paratypes. ♂ 2♀ paratypes in University of Utah Collection, others in American Museum Collection.

Known localities: 123.45, ♀, Oregon: 5 mi. So. Forest Grove; November 28, 1940; Wilton Ivie. (U. U.) 123.44, 3♂ 6♀, Type locality. 123.44, 2♀, Oregon: Salem; March, 1940; J. C. Chamberlin. (U. U.) 123.44, 4♀, Oregon: Spencer's Butte, Eugene; March 29, 1942; Borys Malkin and John Sadler. (2♀–U. U., 2♀–A. M.) 123.44, ♂ 3♀, Same; April 26, 1942; Borys Malkin. (A. M.) 123.44, 2♀, Oregon: Eugene; March 19, 1942; Borys Malkin. (A. M.)

Amaurobius enus new species

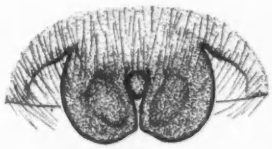
Figures 14, 23

Color essentially typical, with these modifications: Carapace of male with fine reticulate markings on the head and sides, and with dusky radial streaks. Sternum of male dusky; normal, or slightly darkened, in female. Legs of male more or less shaded with dusky, with two pale stripes on dorsal side of each tibia. Dorsal pattern of abdomen usually obscure or absent; when present, it is usually in the form of two irregular parallel bands extending the full length of the abdomen.

Structure: Both eye rows slightly procurved. Anterior median eyes about the same size as the posterior medians. A. m. eyes a little more than a radius apart, about two diameters from the side eyes. P. m. eyes a little less than 2 diameters apart, 3.5 to 4.0 diameters from the side eyes. Median ocular quadrangle about as wide behind as long. Epigynum similar to that of *bennetti*, but the posterior margin usually more smoothly rounded. The palpus is very close to those of *bennetti* and *canada*. The mesal spur of the tibia is a little longer than in *bennetti*, is pointed more directly forward, and the mesal margin is less undulate. The mesal spur is straighter than that of *canada*. The more significant spine variations on the legs of the female are as follows:

EXPLANATION OF PLATE IV

18. *Amaurobius nomeus* Chamberlin, epigynum. 19. *Amaurobius tamarus* n. sp., epigynum. 20. *Amaurobius pictus* Simon, epigynum. 21. *Amaurobius kamelus* n. sp., epigynum. 22. *Amaurobius bennetti* (Blackwall), epigynum. 23. *Amaurobius enus* n. sp., epigynum. 24. *Amaurobius deces* n. sp., epigynum. 25. *Amaurobius olympus* n. sp., epigynum. 26. *Amaurobius nevadensis* Simon, epigynum. 27. *Amaurobius severus* Simon, epigynum.



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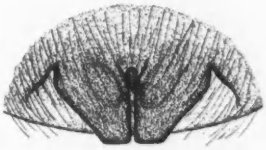

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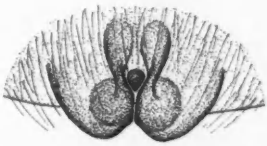

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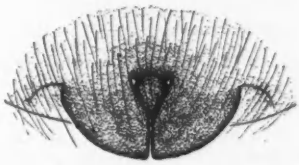

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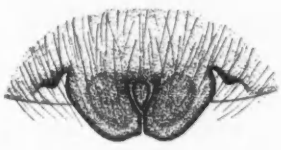

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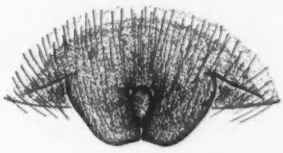

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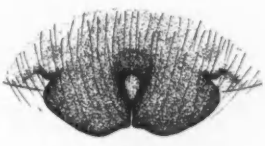

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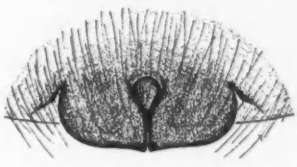

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Femur 1 lacks a distal spine on the posterior side.
Tibia 1 has three spines on the anterior face, above the ventral spines.
Metatarsus 1 with two ventral spines at distal end, with one or two lateral spines near base, and with a distal spine on the anterior corner above.
Femur 3 lacks a median distal spine.
Patella 3 lacks a spine on the anterior side.
Metatarsus 4 lacks a median dorsal spine near the base.

Measurements:

	♂		♀	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	8.20	178	11.30	240
Carapace:				
Length	4.60	100	4.70	100
Width	3.25	71	3.20	68
Tibia-patella:				
1	4.60	100	3.80	81
4	4.70	102	4.00	85

Type locality: W. 116° 2′ : N. 44° 56′. Idaho: 3 miles N. E. of McCall; ♂ holotype, ♀ allotype, ♂ ♀s paratypes, May 31, 1944; ♂s ♀s paratypes, April 28, 1945 (the males were not mature, but were kept alive and matured within two weeks); Wilton Ivie.

Other localities: Quadrangle W. 116° : N. 44°. Idaho: Lost Lake; upper Weiser River; etc.; various dates; many ♀s paratypes; Wilton Ivie.

Types in Collection of University of Utah; ♂s ♀s paratypes in American Museum.

Habitat: Lives mostly in rotten logs in pine woods; also found under pieces of bark, wood, etc., on the ground; and in crevices of trees and buildings. The habitat is very similar to that of ***bennetti*** in the east.

Amaurobius kamelus new species

Figure 21

Female.

Color typical. Pattern on abdomen moderately well developed.

Structure essentially typical, with minor modifications. Anterior median eyes smaller than the others. Posterior eye row straight; anterior row faintly procurved. Anterior median eyes about 0.7 diameter apart, about 2.0 diameters from the side eyes. P. m. eyes about 1.8 diameters apart, about 3.0 diameters from the side eyes. Chelicerae

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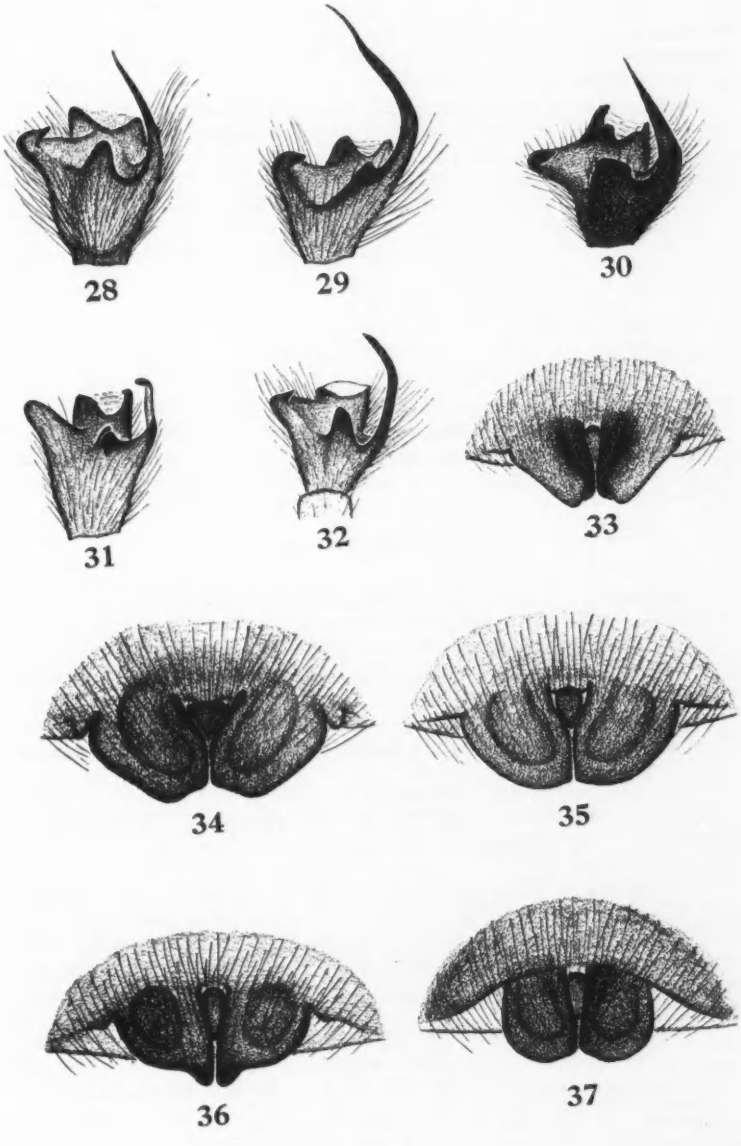
EXPLANATION OF PLATE V

28. *Amaurobius canada* n. sp., dorsal view of tibia of left palpus. 29. *Amaurobius angelus* n. sp., dorsal view of tibia of left palpus. 30. *Amaurobius deces* n. sp., dorsal view of tibia of left palpus. 31. *Amaurobius alaskanus* n. sp., dorsal view of tibia of left palpus. 32. *Amaurobius tacoma* n. sp., dorsal view of tibia of left palpus. 33. *Amaurobius arizonicus* n. sp., epigynum. 34. *Amaurobius canada* n. sp., epigynum. 35. *Amaurobius catalinus* n. sp., epigynum. 36. *Amaurobius severinus* n. sp., epigynum. 37. *Amaurobius olympus* n. sp., epigynum of another specimen.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with 3 teeth on posterior margin of the fang groove. The epigynum shows a peculiar modification in that the mesal side of the lateral lobe is elevated into a rounded ridge, which extends anteriorly. The leg spines show the following variations:

Femur 1 without a distal spine on the posterior side.
Metarsus 1 with one distal ventral spine, without lateral spines near base.
Patella 3 with a spine on the anterior side.
Metatarsus 4 without a median dorsal spine near base.

Measurements:

	♀ Holotype		♀ Paratype	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	9.20	230	10.00	210
Carapace:				
Length	4.00	100	4.80	100
Width	2.67	67	3.20	67
Tibia-patella:				
1	3.67	92	4.30	90
4	3.60	90	4.20	87

Type locality: W. 118° 28′ : N. 45° 28′. Oregon: Meacham Lake, Blue Mts.; ♀ holotype, ♀ paratype; July 4, 1938; Wilton Ivie collector. Found under stones near the bottom of a shady ravine. (University of Utah.)

Amaurobius melanus new species

Immature.

Color dark. Carapace dull, dark brown. Chelicerae dark chestnut brown. Labium and endites reddish brown. Sternum dusky brown, paler in the middle. Legs brown. Abdomen entirely dense black.

Structure essentially typical. The leg spines show the following modifications:

Metatarsi 1 and 2 have only one distal ventral spine.
Femur 3 with or without distal median spines, without lateral spines near base.
Patella 3 without a spine on the anterior side.

Type locality: W. 121° 55′ : N. 36° 38′. California: Pacific Grove; September 1, 1937; immature holotype, immature paratype; Wilton Ivie collector.

This species is evidently closely related to ***subnomeus***, but is distinguishable from that and the other species by its dense black abdomen. While ***nevadensis***, ***olympus***, ***severus***, and perhaps one or two others may occasionally have a black abdomen in old females, none of them has it in the immature form.

Amaurobius nevadensis Simon

Figures 16, 26

Amaurobius nevadensis Simon, 1884, *Bull. Soc. Zool. France*, 9: 318; *1.
A. nevadensis Banks, 1904, *Proc. Calif. Acad. Sci.*, (3)3: 341.
A. nevadensis Petrunkevitch, 1911, Cat. Spid. Amer., 104.
Amaurobius utahensis Chamberlin, 1919, *Ann. Ent. Soc. Amer.*, 12: 239.

Color typical. Front and sides of head often blackened in the females. Dorsal pattern of abdomen conspicuous in the males and immature, but tends to become obscured or even absent in the adult females.

Structure: Large and robust. Both eye rows slightly procurved. A. m. eyes in the female a little larger than the p. m. eyes, or about the same size. A. m. eyes about a radius apart, about two diameters from the side eyes. P. m. eyes about two diameters apart, about 4 diameters from the side eyes. The principal variations in the leg spines of the females are these:

Femur 1 usually without, occasionally with, a distal posterior spine.

Tibia 1 with 1 or 2 spines on anterior face.

Metatarsus 1 with two ventral spines at distal end below (occasionally only one), with one or two lateral spines near base, at least on one side of spider.

Femur 3 without a median distal spine.

Patella 3 with or without an anterior spine.

Metatarsus 1 without a median dorsal spine near base.

Measurements:

	♂		♀	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	11.70	188	15.00	227
Carapace:				
Length	6.20	100	6.60	100
Width	4.53	73	4.50	68
Tibia-patella:				
1	7.15	115	6.67	101
4	7.20	116	6.52	99

Type locality: "Nevada."

Known localities: 111.41, ♀, Utah: Ogden Canyon; May 7, 1927; R. V. Chamberlin. 111.40, 4♂ 4♀, Utah: Hughes Canyon, near Holladay; May 30, 1934; W. Ivie. 111.40, ♂s ♀s, Utah: Many localities in Wasatch Mts.; various dates. 112.38, ♂, Utah: Fillmore; August, 1917; R. V. Chamberlin. (Chamberlin, 1919; type of *A. utahensis*. M. C. Z.) 119.39, 3♀, Nevada: Reno; Jan. and July, 1940; University of Nevada. 119.37, California: Pine Ridge; Clark. (Banks, 1904.) 119.37, ♂ 4♀, California: Aspen Valley, Yosemite Park; August 11, 1931; Wilton Ivie. 119.37, ♀, California: Mammoth Lakes; August 18, 1941; W. M. Pearce. (American Museum.) 120.39, California: Sierra Co.; Fuchs. (Banks, 1904.) 120.39, 2♀, California: Emigrant Gap; August 23, 1932; S. D. Durrant. 120.39, ♀, Same; July 16, 1937; R. V. Chamberlin. 120.38, 4♀, California: near Riverton; July 15, 1934; Wilton Ivie and Herman A. Rasmussen. 121.36, ♀, California: Pacific Grove; August 5, 1931; R. V. Chamberlin. 122.42, ♀, Oregon: Pinehurst; September 9, 1935; R. V. Chamberlin and Wilton Ivie. 122.41, 4♀, California: Weed; September 8, 1935; R. V. Chamberlin and Wilton Ivie. 122.38, California: Marin County; Vaslit. (Banks, 1904.)

Amaurobius nomeus Chamberlin

Figures 11, 18

Amaurobius nomeus Chamberlin, 1919, *Ann. Ent. Soc. Amer.*, 12: 240; *14: 1-2.
A. nomeus Gertsch & Jellison, 1939, *Amer. Mus. Novitates*, 1032: 2.

Color: Brighter than usual, as in *pictus*. The front and sides of the head in the female conspicuously darkened. Sternum lightly shaded with dusky. Legs without traces of annuli (present in *pictus*) Abdomen with the light markings large and distinctive.

Structure: Both eye rows of female procurved. A m. eyes fully as large as the p. m. eyes or larger, about a radius apart, a little more than a diameter from the side eyes. P. m. eyes nearly two diameters apart, about 2.5 diameters from the side eyes. Median ocular quadrangle wider behind than long. The more significant spine modifications are as follows:

Femur 1 without a distal spine on the posterior side.
Metatarsi 1 and 2 with one distal ventral spine; without lateral spines near base.
Femur 3 without a median distal spine.
Patella 3 without a spine on the anterior side.
Metatarsus 4 without a median dorsal spine near base.

Measurements:

	♀	
	Mm.	*Ratio*
Length	10.00	217
Carapace:		
Length	4.60	100
Width	3.15	68
Tibia-patella:		
1	3.90	85
4	3.95	86

Type locality: About W. 111° 3′ : N. 40° 45′. Utah: Chalk Creek, Uintah Mts., 10,000 ft. elev.; ♂ ♀ types; August, 1917; R. V. Chamberlin collector. (M. C. Z.)

Known localities: 107.38, ♀, Im., Colorado: Ouray; June 19, 1940; Wilton Ivie. 110.44, 3♀, Wyoming: Bridge Bay, Yellowstone Park; July 9, 1938; W. Ivie. 110.40, ♀, Utah: Mirror Lake, Uintah Mts.; August 18, 1942; W. Ivie. 111.45, ♀, Montana: Galatine Gateway; August 14, 1929; R. V. Chamberlin. 111.40, ♂ ♀, (Type locality). Types. 111.40, 3♀, Utah: upper Provo River; June 19, 1941; Wilton Ivie. 111.39, 2♀, Utah: Ferron Reservoir, Wasatch Plateau; June 24, 1934; Wilton Ivie and Herman A. Rasmussen. 112.37, 2♀, Utah: Cedar Mountain; August 1, 1935; A. M. Woodbury. 114.48, ♀, Montana: La Salle; August, 1934; Chas. Jellison, Jr. (Gertsch and Jellison, 1939.) 114.46, 2♀, Im., Montana: Moose Lake, Ravalli Co., May 6, 1934 (♀); Skalkaho Divide, July 15, 1934 (Im. ♀); Gird's Cr. Ravalli Co., August 26, 1934 (♀); W. L. Jellison. (Gertsch and Jellison, 1939.)

These spiders are typically found under the bark of dead pines and in crevices at high elevations.

Amaurobius olympus new species

Figures 15, 25, 37

Color typical. Dorsal pattern on abdomen obscure or only moderately developed.

Structure: Essentially typical. The male palpus has the mesal spur of the tibia unusually long and slender; the middle lobe is distinctly separated from the mesal spur. Female: Eye rows faintly procurved. A. m. eyes usually slightly larger than the p. m. eyes; about a radius apart, about 1.7 diameters from the side eyes. P. m. eyes about 1.6 diameters apart, about 3.0 diameters from the side eyes. Median ocular quadrangle about as wide behind as long. The principle spine modifications on the legs are these:

Femur 1 usually without a distal spine on posterior side.
Tibia 1 with 0 to 2 spines on anterior face.
Metatarsus 1 with two distal ventral spines, without lateral spines near base.
Femur 3 without a median distal spine.
Patella 3 without an anterior spine.
Metatarsus 4 usually without a dorsal median spine near base.

Measurements:

	♂ Holotype		♀ (Large)	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	8.60	200	12.00	210
Carapace:				
Length	4.30	100	5.70	100
Width	3.10	72	3.90	68
Tibia-patella:				
1	5.53	129	5.15	90
4	5.20	121	5.00	88

Type locality: Quadrangle W. 122° : N. 37°. California: King's Mt., near Palo Alto; ♂ holotype; Autumn, 1922; J. C. Chamberlin collector. (Univ. Utah.)

Known localities: (Types and paratypes). 118.34, ♀, California: "Los Angeles"; June. (Amer. Mus.) 121.41, 5♀, California: Bartle, July 21, 1941 (4♀); Dickson Flat, N. E. Shasta Co., July 21, 1941 (♀); W. M. Pearce. (Amer. Mus.) 121.37, ♀, California: Stevens Cr., Santa Clara Co.; April 20, 1941; W. M. Pearce. (Amer. Mus.) 121.36, 2♀, California: Pacific Grove; March, 1913; R. V. Chamberlin. 122.47, ♂ ♀, Washington: Olympia. 122.41, ♀, California: Mt. Shasta City; August 25, 1931; W. Ivie. 122.37, ♂ ♀s, California: vicinity Palo Alto; 1921 to 1923; J. C. Chamberlin. Holotype, allotype, and paratypes. 122.37, 5♀, California: Ingleside. 122.37, ♀, California: Felton; March, 1913; R. V. Chamberlin. 123.42, 4♀, Oregon: Grants Pass; August 29, 1931, W. Ivie (3♀); September 9, 1935, Chamberlin and Ivie (♀).

Amaurobius pallescens (Chamberlin)

Auximus pallescens Chamberlin, 1920, *Pomona Coll. J. Ent. & Zool.*, 12:3, *1: 3.

Color typical. Abdominal pattern indistinct.
Structure essentially typical. A. m. eyes larger than the p. m. eyes.

Type locality: About W. 117° 48′ : N. 34° 3′. California: Claremont; immature ♀ holotype; Wm. A. Hilton collector. (M. C. Z.)

Since the type is an immature specimen, the correct placement of this species must await the examination of adult material from near the type locality.

Amaurobius pictus Simon

Figures 12, 20

Amaurobius pictus Simon, 1884, *Proc. Soc. Zool. France*, 9: 320; *3.
A pictus Banks, 1900, *Proc. Wash. Acad. Sci.*, 2: 482.
A. pictus Banks, 1910, *Bull. U. S. Nat. Mus.*, No. 72: 19.
A. pictus Petrunkevitch, 1911, Cat. Amer. Spid., 105.
A. pictus Emerton, 1919, *Trans. Royal Can. Inst.*, 12: 325.
A. pictus Chamberlin and Ivie, 1946, *Bull. Univ. Utah*, °°

Color: Essentially typical, but with the abdominal markings more extensive and showing greater contrast than in almost any other species. The sternum is dusky in the male, less so in the female. The legs usually show some faint annuli.

Structure: ♀. Both eye rows procurved. A. m. eyes slightly larger than the p. m. eyes, a little more than a radius apart, about 1.3 diameters from the side eyes. Median ocular quadrangle about as long as the posterior width. Chelicerae usually with three teeth on the hind margin of the fang groove, sometimes four. ♂. Similar to female, but with the typical modifications of the male, although these are less extreme than in certain other species. The tibia of the palpus has the median process very short, it being much shorter than the middle process. The spine modifications on the legs of the female are as follows:

Femur 1 with a posterior distal spine above.
Metatarsus 1 with one distal ventral spine, without lateral spines at base.
Femur 3 with a median distal spine above.
Patella 3 with an anterior spine.
Metatarsus 4 with or without a median dorsal spine near base.

Measurements:

	♂		♀	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	8.60	200	9.20	200
Carapace:				
Length	4.30	100	4.60	100
Width	3.10	72	3.07	67
Tibia-patella:				
1	5.00	116	4.60	100
4	4.90	114	4.50	98

Type locality: "Washington State."

Known localities: 121.47, ♀, Washington: Snoqualmie Pass; Aug. 11, 1929; R. V. Chamberlin. 122.48, 2♀, Washington: Chehallis; Sept. 10, 1935; Chamberlin and Ivie. 122.47, 2♂ 2♀, Washington: Olympia. 122.47, 2♀, Washington: Tacoma; August 9, 1929; R. V. Chamberlin. 122.45, 2♀, Oregon: Portland. 122.45, ♀, Oregon: Perham Cr., Columbia Gorge; August 4, 1929; R. V. Chamberlin.

123.48, 2 ♀, British Columbia: Sidney, Vancouver Is.; Sept. 16, 1935; R. V. Chamberlin and W. Ivie. 123.45, Imm., Oregon: N. E. Mohler; August 25, 1936; Wilton Ivie. 123.44, ♀, Oregon: 8 mi. So. Salem; April 24, 1941; J. C. Chamberlin. 123.43, 2 ♀, Oregon: Comstock; Sept. 8, 1935; Chamberlin and Ivie. 124.49, ♂ 5 ♀, B. C.: Port Alberni, Sept. 12, 1935; Lake Cameron, Sept. 13, 1935; R. V. Chamberlin and W. Ivie. ♂, B. C.: Florence Lake; November 3, 1928. B. C.: Departure Bay, Vancouver Is.; J. H. Keen (Emerton, 1919.) 130.54, Alaska: Fox Point; July 26–27, 1899; Trevor Kincaid (Banks, 1900.) 134.58, 2 ♀, Alaska: Juneau; April 28–29, 1945; J. C. Chamberlin. 135.59, ♀, Imm., Alaska: Haines; August 20–25, 1945; J. C. Chamberlin. 151.60, Alaska: Cook Inlet; July, 1899; Trevor Kincaid (Banks, 1900.)

Amaurobius severinus new species

Figure 26

Female.

Color: Carapace light brown, slightly darker on front of head. Chelicerae chestnut brown. Labium and endites reddish brown. Legs and palpi brownish yellow, with distal part of leg 1 and palpus darker. Abdomen gray; dorsal pattern obscure.

Structure: Very similar to *severus*, except for much smaller size. Anterior eye row about straight; a. m. eyes 0.4 diameter apart, 1.3 diameters from the side eyes. Posterior row procurved, p. m. eyes 1.7 diameters apart, 2.8 diameters from the side eyes. Anterior median eyes a little larger than the p. m. eyes. Epigynum similar to that of *severus*. Leg spination modified as follows:

Femur 1 with or without distal spine on posterior side.
Tibia 1 with 0 or 1 spine on anterior face.
Metatarsus 1 with two ventral spines at distal end, with or without lateral spines at base.
Patella 3 without spine on anterior side.
Femur 3 without median distal spine above.

Measurements:

	♀ 1	♀ 2	*Average*	*Ratio*
Length	10.00	10.00	10.00	217
Carapace:				
Length	4.80	4.40	4.60	100
Width	3.36	3.08	3.22	70
Tibia-patella:				
1	4.15	4.13	4.14	90
4	4.27	4.25	4.26	93

Type locality: W. 121° 5′ : N. 35° 28′. California: Cambria, September 16, 1937; ♀ holotype, 2 immature paratypes (Amer. Mus.) ♀ paratype (Univ. Utah.)

Amaurobius severus Simon

Figures 17, 27

Amaurobius severus Simon, 1884, *Bull. Soc. Zool. France*, 9: 319, *2.
A. severus Petrunkevitch, 1911, Cat. Spid. Amer., 105.
A. severus Emerton, 1919, *Trans. Royal Canadian Inst.*, 12: 325.

Color: Carapace brownish orange to reddish brown, more or less shaded or blackened on the front of the head. Chelicerae chestnut brown. Endites and labium dark brown in the female, brownish orange in the male; the endites with whitish tips. Sternum, legs, and palpi brownish orange; the distal segments of the male palpus more brownish. Abdomen dark gray to blackish, with a moderately developed pattern of light gray on the dorsum; lighter gray on the venter (in old females, the abdomen tends to become darker and the pattern obscured). Spinnerets orange brown. Epigynum reddish brown.

Structure: ♀. Size large. Head broad and robust. Both eye rows slightly procurved. A. m. eyes larger than p. m. eyes, less than a radius apart, 1.6 diameters from the side eyes. P. m. eyes 2.0 diameters or more apart, about 4.0 diameters or slightly less from the side eyes. Epigynum wide and transversely straight across the posterior edge. The more variable leg spines are as follows:

Femur 1 with a posterior distal spine.
Metatarsus 1 and 2 with two ventral spines at distal end, with one or two lateral spines near base.
Femur 3 usually with a median distal spine.
Patella 3 with or without an anterior spine.
Metatarsus 4 without a median dorsal spine near base.

♂. Typical, with the usual variations characteristic of the male, although these appear to be more extreme than usual. Palpus stout; the ectal spur of the tibia of medium length, only a little more than twice as long as the middle spur.

Measurements:

	♂		♀	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	11.80	197	15.00	217
Carapace:				
Length	6.00	100	6.90	100
Width	4.27	71	4.83	70
Tibia-patella:				
1	6.90	115	6.80	98
4	6.90	115	6.67	96

Type locality: "Washington State."

Known localities: 119.37, ♀, California: Aspen Valley, Yoemsite Park; August 11, 1931; W. Ivie. 119.34, 3♀, California: Goleta; July 12, 1934; H. A. Rasmussen and W. Ivie. 121.36, ♀, California: Pacific Grove; Winter, 1932; Pearl Murray. 122.48, 4♂ 4♀, Washington: Chehallis; September 10, 1935; R. V. Chamberlin and Wilton Ivie. 122.47, ♀, Washington: Olympia. 122.38, 2♀, California: Marin County. 122.37, ♂ ♀, California: Atherton; December, 1927; J. C. Chamberlin. 122.37, ♂ ♀, California: San Francisco. 122.37, ♀, California: Berkeley. 123.49, 2♂ ♀, British Columbia: Nanaimo; Sept. 13, 1935; Chamberlin and Ivie. 123.48, ♂ ♀, B. C.: Sidney; Sept. 16, 1935; Chamberlin and Ivie. 123.48, ♂ 6♀, Washington: Sequim; J. M. Grant. 123.44, 2♀, Oregon: Corvallis. 124.49, ♂ 3♀, B. C.: Lake Cameron; Sept. 13, 1935; Chamberlin and Ivie. B. C.: Departure Bay, Vancouver Is. (Emerton, 1919.)

Amaurobius shastus new species

Female.

This species closely resembles *enus* in size, color, and structure, but can be separated from it on the basis of the leg spination in the female. In *shastus*, metatarsus 1 lacks the distal spines above, as well as the lateral spines near the base. It also has, occasionally or frequently, the following spines: A median distal spine on femur 4, an anterior spine on patella 3, a small dorsal median spine near base of metatarsus 4. The epigynum is similar to that of *enus*.

Measurements:

	♀	
	Mm.	*Ratio*
Length	10.00	204
Carapace:		
Length	4.90	100
Width	3.33	68
Tibia-patella:		
1	4.10	84
4	4.20	86

Type locality: W. 122° 25′ : N. 41° 25′. California: Weed; September 8, 1935; ♀ holotype, 8 ♀s paratypes; R. V. Chamberlin and Wilton Ivie collectors. Found in rotten logs.

Amaurobius subnomeus new species

Female.

Color: Carapace yellowish to orange brown, dusky brown on the front and sides of the head. Chelicerae blackish brown. Labium and endites dark brown, with narrow whitish tips. Sternum yellowish, shaded with dusky, especially on the margins. Legs and palpi light brownish yellow. Abdomen gray, with the spots of the dorsal pattern largely coalesced, but distinct.

Structure: Close to *nomeus* and *pictus* in general appearance. It differs from *pictus* by lacking the spine on the anterior side of patella 3, and from *nomeus* by possessing a distal median spine on femur 3. The epigynum is very similar to that of *pictus* (see fig. 20).

Measurements:

	♀	
	Mm.	*Ratio*
Length	9.30	202
Carapace:		
Length	4.60	100
Width	3.30	72
Tibia-patella:		
1	4.60	100
4	4.40	96

Type locality: W. 121° 55′ : N. 36° 38′. California: Pacific Grove; ♀ holotype, ♀ paratype, August 18, 1932, S. D. Durrant; ♀ and immature paratypes, July 13, 1934, H. Rasmussen and W. Ivie; ♀ paratype, August 17, 1931, W. Ivie.

Amaurobius tacoma new species

Figure 32

Male.

Color: Carapace yellowish brown; sides of head reticulated with dusky. Chelicerae reddish brown. Endites orange. Sternum and labium dusky yellow. Legs light yellowish brown, with faint dusky annuli. Abdomen dark gray, with a distinct whitish pattern above, as in *pictus*.

Structure: Essentially typical. A. m. eyes slightly larger than the p. m. eyes, about 0.8 diameter apart, 1.2 diameters from the side eyes. Posterior row procurved; p. m. eyes about 1.6 diameters apart, 2.5 diameters from the side eyes. Palpus with mesal spur of the tibia slightly more than twice as long as the middle spur; it is bent mesad at about three-fifths of its length from the base, and is rather slender and uniform in thickness from base to near the tip.

Measurements:

	♂ Holotype	
	Mm.	*Ratio*
Length	8.00	187
Carapace:		
Length	4.27	100
Width	2.93	68
Tibia-patella:		
1	5.20	122
4	5.25	123

Type locality: W. 121° 44′ : N. 46° 47′. Washington: Paradise Valley, Rainier Park; August 10–12, 1942; Borys Malkin. (American Museum.)

Amaurobius tamarus new species

Figures 6–10, 19

Color essentially typical, but tends to be lighter than usual. The sternum is not darkened. The labium and endites of the female are reddish brown. The abdominal pattern is typical, but sometimes lacks sharp contrast. The carapace of the male is unmarked.

Structure essentially typical. Eye rows about straight. A. m. eyes smaller than the p. m. eyes. Some of the more significant spine characters are as follows:

Male:

Metatarsi 1 and 2 with only one distal ventral spine.

Female:

Femur 1 with or without a distal spine on the posterior side.
Tibia 1 with one to three spines on the anterior face.
Metatarsus 1 with one ventral spine at distal end, without lateral spines near the base.
Femur 3 with a median distal spine above.
Patella 3 with a spine on the anterior side.
Metatarsus 4 with a small median dorsal spine near base.

Male palpus with the ectal process short, it being less than twice as long as the middle spur.

Measurements:

	♂ Holotype		♀ Allotype	
	Mm.	*Ratio*	*Mm.*	*Ratio*
Length	9.30	207	8.30	208
Carapace:				
Length	4.50	100	4.00	100
Width	3.20	71	2.70	68
Tibia-patella:				
1	5.60	124	3.60	90
4	5.20	115	3.65	91

Type locality: W. 116° 28′ : N. 44° 57′. Idaho: Lost Valley Reservoir; August 20, 1936; ♂ holotype, ♀ allotype, ♂ ♀ paratypes; July 27, 1939, 8 ♀ paratypes; Wilton Ivie collector.

Other locality: 117.46, ♀, Washington: Wawawai.

DDT AND THE INSECT PROBLEM, by JAMES C. LEARY, WILLIAM I. FISHBEIN and LAWRENCE C. SALTER. VII. 176 pages. McGraw-Hill Book Company, Inc., 1946. Price $2.50.

This timely little book is well printed, well illustrated and well written, and is attractively bound to boot. Although its avowed purpose is to present a summary for the user rather than a scientific treatment of the subject, it seems likely to provide valuable information even for entomologists unless they have been actively engaged in work with DDT. The reviewer is not among the latter, hence he has found it informative and entertaining as well.

The introductory chapter is a lucid summary of the proved values of DDT as an insecticide and the risks attending its extensive use where man and other animals are incidentally exposed to it. Even though the authors do not pretend to offer an exhaustive scientific survey, their treatment here seems reassuringly ample and judicious.

The chapter on Insects and Insecticides is brief and rather ordinary to an entomologist but should be informative to other readers.

Chapter III, on the Chemistry and Pharmacology of DDT, includes a discussion of the composition and manufacture of the substance and of its physiological effects. Even though brief it is an excellent and practical treatment of the action of the poison, the dangers attending its use, and methods of treatment in cases of poisoning.

The five remaining chapters cover methods of using DDT, its use in the war, its effectiveness in protecting man from the attacks of insects, and its use in agriculture and against forest, shade and fruit tree insects.

In spite of its small size the book is packed with information. It should be extremely valuable to anyone who has occasional use for insecticides and an excellent addition to the libraries of professional entomologists as well.—A. W. L.

A LABORATORY METHOD OF REARING CHIGGERS AFFECTING MAN

(Acarina: Trombiculidae)

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INTRODUCTION

The object of this research was to discover a method of rearing chiggers experimentally in the laboratory in order to provide colonies for the purpose of disease transmission studies of scrub typhus, and to provide chigger larvae for testing new acaricides and repellents under controlled laboratory conditions during the entire year. A second object was to obtain information about the little known but common pest species of chiggers affecting human beings in the United States.

Until the present study, chiggers had not been successfully reared through more than one generation, or reared through a single generation without very high mortalities. Numerous attempts have been made by workers to rear chiggers, but the exacting and different food or environmental requirements of each stage of the complex life history has prevented complete success in establishing a colony.

The first attempts to rear chiggers were made about 1917 by the Japanese in relation to the scrub typhus disease. The life cycle from larva to adult of the chigger ***Trombicula akamushi*** was described independently by Nagayo et al (1917), Miyajima and Okumura (1917), Kitashima and Miyajima (1918). They were able to feed the larvae on mice, and reared a few nymphs to adults by feeding pieces of melons, potatoes, and other vegetagles. One adult contained eggs, but no second generation larvae were obtained from reared adults.

Ewing (1944) fed chigger larvae on turtles and toads, and reared nymphs of ***Eutrombicula alfreddugesi*** in the United States on feces of millipedes and springtails and obtained two adults. Blade et al (1945) working on scrub typhus in the New Guinea area, reviewed the literature in detail and state, "Attempts to carry mites through a complete cycle of development in the laboratory have not been successful. This has limited the scope of observations on experimental transmission of mite typhus." Melvin (1946), Michener (1946a) (1946b) and Jenkins (1946) working at Gorgas Memorial Laboratory, Panama City R. de P., reared ***Eutrombicula batatas*** (=***hominis***?) through its complete life history, but in no case was a method discovered of rearing enough chiggers to enable a colony to be maintained. Melvin used chicks as larval hosts and reared nymphs and adults in soil containing chicken feces. He mentions "mass culture methods" and "two or more" generations. Michener later made a very careful study and described the stages of the life history in detail. Using chicks as host animals and chicken feces as larval and adult food, he obtained about 10% adults from larvae, but

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had difficulty in getting the reared adults to lay eggs. Wharton and Carver (1946) and Wharton (1946), in detailed rearing experiments for the Navy on *Ascoschöngastia indica* in Guam, discovered that insect eggs are satisfactory food for the nymphs and adults, but reported difficulty in getting the larvae to engorge. Wharton (1946) in reviewing his own and all other published data (to July, 1946), stated, "No entirely satisfactory system for culturing trombiculid mites has yet been described."

Each of the investigators made valuable contributions to the knowledge of the species being studied and this information has been of advantage in starting the present colonies of the species of chiggers which affect man in the United States.

The common "chiggers" or "red bugs" which cause so much discomfort to human beings in many parts of the United States have been little investigated. The habits, hosts, life histories, distributions, and disease relationships have not been adequately studied. World War II aroused much interest in chiggers because of their importance as disease vectors of scrub typhus or "tsutsugamushi" which became a serious problem to the Armed Forces stationed in the Southwest Pacific where the disease is indigenous. Chiggers were also noxious pests during Army maneuvers in the southern part of the United States.

Three species of chiggers are known to affect human beings in the United States, and all of these species were successfully reared in the laboratory by the author. These mites are in the genus *Eutrombicula* which is nearly world wide in distribution. Two of the species, *Eutrombicula alfreddugesi* and *Eutrombicula masoni* are serious widespread pests of man, while the third, *Eutrombicula batatas* (=*hominis*?), is uncommon and restricted to only the southeastern part of the United States.

The life history of the chigger is comparatively complex and consists of seven stages which are: egg, deutovum, larva, nymphochrysalis (protonymph), nymph, imagochrysalis (preadult), and adult. The larvae, nymphs, and adults are the only active feeding and growing stages, while the others are resting or transition stages between the active forms.

PROCEDURE AND METHODS

The first rearing experiments were carried on in Panama from December, 1945, to March, 1946, and from then until March, 1947, in the United States in Florida, Texas, Maryland, and Ohio. The first rearing methods used in Panama were designed after Michener's (1946b), but eggs of the mosquito *Anopheles albimanus* were used as food for the nymphs and adults of *Eutrombicula batatas* and *Trombicula alleei*. These were reared through a complete generation but the mortality was still about 60% and second generation egg production was unsatisfactory. These methods were not suitable for rearing *Eutrombicula alfreddugesi* and *E. masoni* in the United States so that new methods and types of equipment were developed.

The rearing techniques, foods and equipment here described have been standardized as a result of continued testing. The factors which caused mortality and difficulties in rearing are included to prevent similar trouble to future workers. Methods and rearing containers were

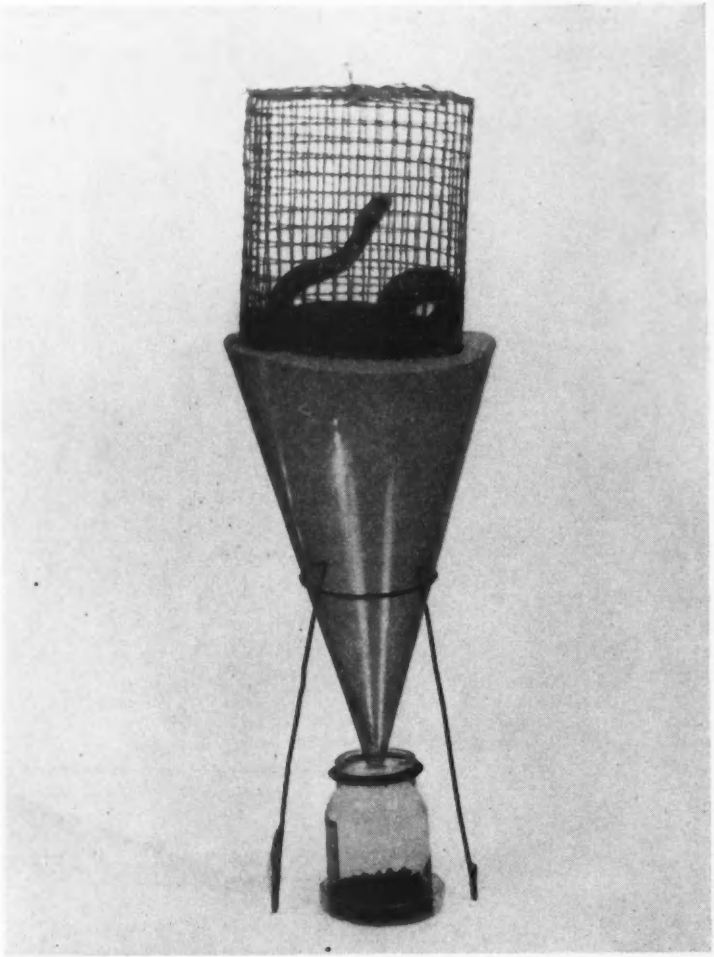
continually modified during the research in order to (a) increase the per cent of survival in each stage, (b) reduce the length of time required for each generation, and (c) to reduce the time and individual handling required in rearing the colonies.

The laboratory colonies were started with larvae since they were the most abundant and easiest to obtain in the field. Adults, nymphs, and other stages were collected and reared, but they could not be obtained in sufficient quantities. Engorged larvae were obtained in large numbers by collecting the larvae from naturally infested vertebrate hosts, e. g., 11,000 larvae from one black snake, and allowing the larvae to remain on the hosts until fully engorged. Unfed larvae were collected in the field by use of the black collecting boards shown in Plate IV, which were placed in areas with a high population of chiggers.

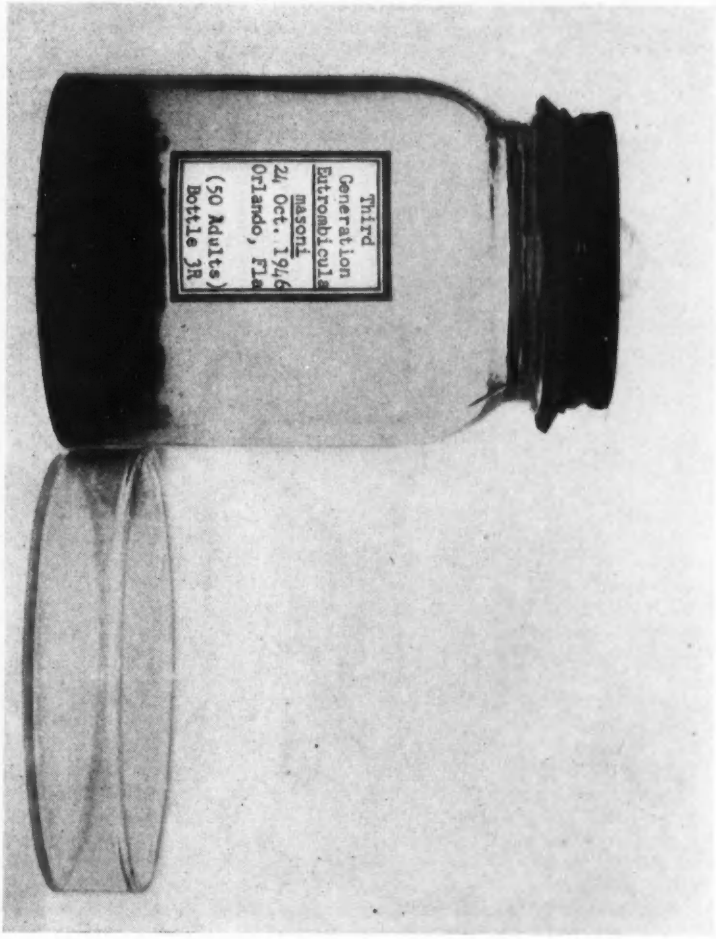
Larval hosts and engorgement: The chigger larvae would not develop further in their life history unless they attached and engorged on a vertebrate animal. A number of types of vertebrate animals were tested as hosts. In Panama, the author used small chicks with success as hosts in feeding larvae of *Eutrombicula batatas* and *Trombicula alleei*. Chicks were rather poor laboratory animals, however, because of the feeding and attention which they required. Their feces and spilled food trapped the engorged chigger larvae which detached and fell from the host into the rearing jar or tray of water beneath. Mice and other mammals presented the same laboratory disadvantages.

A number of species of snakes, lizards, and turtles were tested as hosts in Florida. It was found that unfed *Eutrombicula alfredugesi* and *E. masoni* larvae would attach to these reptiles and engorge, producing healthy nymphs. Of the reptiles tested, the common box turtles *Terrapene carolina* (including the subspecies *carolina*, *bauri*, and *major*) proved to be the best host and laboratory animals. They are easily handled, require little care and survive well when fed only at intervals between experiments, so that there is little contamination by feces of the collecting funnel or rearing jar below. Another advantage of using turtles is that they molt only about once a year while snakes and lizards molt much more frequently and are more difficult to handle. Box turtles are important natural hosts and contribute much in causing high chigger populations in some areas. Snakes on the other hand sometimes have a higher number of attached larvae when collected in the field and the larvae are often larger and more fully engorged.

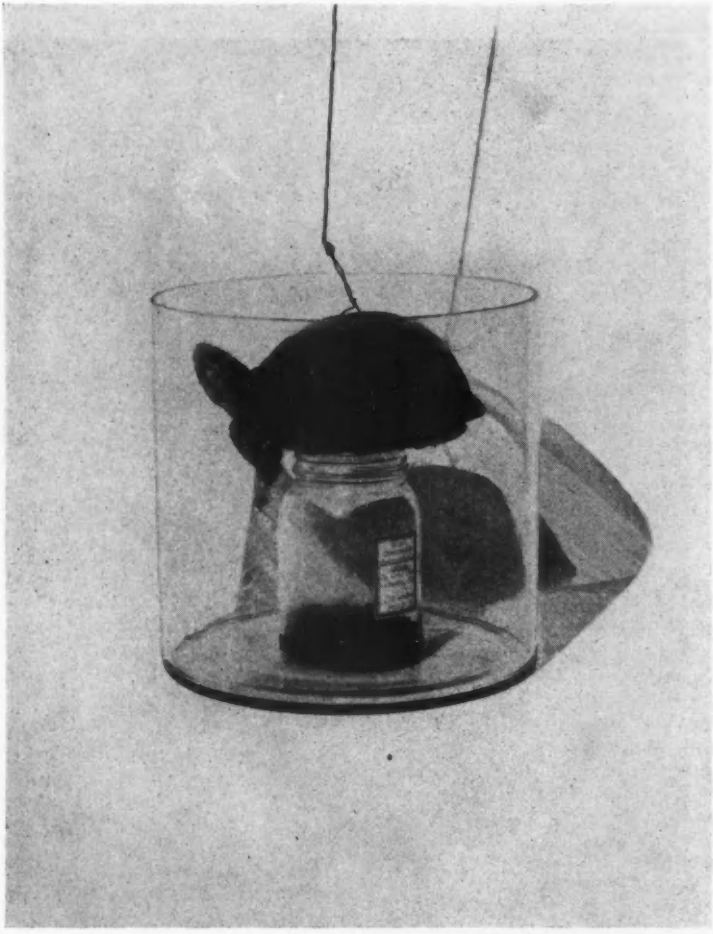
The turtles and snakes were placed in wire mesh cages and suspended above collecting funnels which were suspended over the rearing jars as shown in Plate I. When the larvae were fully engorged, they detached from the host and dropped into the collecting funnel and were concentrated into the moist soil in the bottom of the rearing jar. The circular cage was made of one-half inch mesh rabbit screen and could be opened at the top. The collecting funnel was made of celluloid. A thin layer of vaseline was spread around the inner lip of the top and the outer lip of the bottom of the funnel to prevent larval escapes. The cage and funnel were suspended separately so that the funnel did not touch either the cage or rearing jar. This method collected 100% of the larvae into the rearing jar with no individual handling as was required when using cages with a tray of water beneath as described by Michener (1946b).



Cage containing a black snake host suspended over a collecting funnel and rearing jar. After engorgement, the chigger larvae detach from the host and fall into the rearing jar.



Rearing jar used for all stages of the life history except feeding the larvae. The jar is kept in the petri dish.



Turtle host suspended over rearing jar to transfer reared larvae to host for obtaining new generations. Note vaseline ring at top of bell jar to prevent chigger escapes.

Black cardboard used to attract and collect ungorged larvae in the field for testing miticides and making identifications.

Engorgement of the larvae on the box turtle in central Florida required an average of about eight days, early and late in the season, but in the warmest period during July and August, only three or four days were required for engorgement of the majority of the larvae.

Turtles and snakes were collected in the field and daily counts were made of the engorged larvae which dropped off. When all larvae had detached, the chigger free turtles were staked out for periods of one to five hours in areas with high chigger populations. About 500 larvae was considered to be a good infestation. The larvae did not appear to cause any discomfort or damage to the turtles or snakes, and no swelling or abscesses occurred as in birds and mammals.

Rearing container: The container for rearing chiggers must meet several exacting requirements in the different stages of the life history. An air temperature between 25° and 35° C. and a relative humidity of about 85% to 100% should be maintained without any droplets of water being formed on the inside of the container. The medium or substrate must be nearly saturated, but should allow free movement of the animals in the interstices, and should not have any poisonous properties. Sufficient ventilation is needed even though the container must be sealed tight enough to prevent escape of the minute unfed larvae.

The rearing jar shown in Plate II, has been perfected to take care of all stages of the life history except during the engorgement of the larvae on the vertebrate host. After many failures, the jar finally adopted was made in the following way: The bottom inch was cut off of a pint glass screw top jar. The two and one-half inch metal lid had a half-inch hole drilled in the center and was plugged with cotton to provide ventilation and to help prevent steaming or water condensation inside the jar. The open bottom of the jar was plugged with a three-eighths inch layer of plaster of Paris containing about 10% activated charcoal. After drying, the plaster of Paris was covered with a thin layer of activated charcoal to absorb all odors and to cover any poisonous elements of the plaster. A layer of sterilized humus or moist sandy soil about one-fourth inch in depth was placed in the jar. The sandy soil contained some humus after screening. It was found that coarse sand particles prevented packing of the soil and allowed freer movement of the chiggers. The soil was collected from areas in the field having a high chigger population, and was sterilized for one hour in an autoclave at 20 lbs. pressure to prevent possible contamination of the cultures.

In earlier experiments, engorged larvae were placed in a half-pint clamp top mason jar coated on the inside with a thin layer of plaster of Paris as described by Michener (1946b). The engorged larvae and the following stages, the nymphochrysalis and nymph require nearly 100% humidity. At this humidity, condensation of water droplets occurs in the bottle on the glass, and the engorged larvae are entrapped and die. A thin layer of plaster of Paris lining in the bottle allows a 100% humidity without any moisture droplets. This worked quite well with *Eutrombicula batatas* and *Trombicula alleei* in Panama, but heavy mortalities resulted when rearing the United States species. Addition of activated charcoal to the plaster of Paris resulted in less mortality and healthier nymphs. Use of this plaster of Paris lined bottle necessitated extra handling and involved transfer of the nymphs to the rearing jar

containing soil. This handling resulted in about a 10% loss and injury to specimens so that a new method was developed.

In the method finally adopted, the engorged larvae dropped directly from the vertebrate host animal into the rearing jar containing soil, and the nymphs and adults were reared with no additional handling. A narrow ring of vaseline was coated inside the jar about one-half inch above the soil to prevent larvae from crawling up the glass. The soil in the jar was moistened daily by adding water from a medicine dropper, and the excess drained out through the plaster of Paris bottom into a petri dish in which the bottle was placed. After an average of two days, the larvae turned into the nymphochrysalis resting stage, and nymphs hatched in about one week.

The rearing bottles were kept at a temperature of 28° to 32° C., but extremes in temperature of 24° and 36° C. were observed at times. In September, the colony was placed in a temperature chamber and the temperature was maintained between 28° and 30° C. The relative humidity of the rearing jars ranged from 86% to 100% using wet-dry bulb thermometers for measuring the humidity.

Nymph and adult rearing: The habitat and food requirements of the nymphs and adults are similar, and the rearing jar described above is suitable for their culture. The nearly saturated sterilized sandy soil provided a satisfactory substrate or medium. No individual handling or care was necessary other than daily moistening and feeding at weekly intervals. The temperature and relative humidity was maintained the same as for previous stages.

The best food for the nymphs and adults was found to be insect eggs as reported by Wharton and Carver (1946). Feces from chickens and other animals, and vegetable material was not considered to be suitable food. In Panama, the present author fed the eggs of the malaria mosquito ***Anopheles albimanus*** to the nymphs and adults with fairly good results. In the United States, the eggs of the yellow fever mosquito ***Aedes aegypti*** were fed with excellent success. Eggs of other insects such as the housefly and Drosophila were also tried, but they hatched after a few hours and could not be stored. ***Aedes aegypti*** eggs remained in good condition for a long period, and were ready for use at any time. At first only eggs laboriously excised from the gravid ovipositing female mosquitoes were fed to the young nymphs since they had difficulty in piercing the mature egg shells. It was discovered that moistening the mature eggs slightly, permitted the young nymphs to pierce the egg shell and allowed feeding. If the eggs were moistened too much, the mosquito larvae hatched, rotted, and ruined the culture.

If sufficient food was not provided, the nymphs and adults became cannibalistic and ate each other and probably ate some of the other stages. The growth of the nymphs was rapid, and full size was attained in two or three days if an abundant supply of food was available. Besides moistening the mosquito eggs, it was necessary to maintain an optimum soil moisture and humidity which provided sufficient moisture to prevent drying of the nymphs and adults. An excess of water caused the nymphs to become stuck to the soil or jar and caused death. The nymphs transformed into the imagochrysalis stage in about ten days

and remained inactive for four to nine days before they emerged as mature adults.

To determine the amount of food eaten by adult chiggers, a series of ten adults two days old were starved for 24 hours and then fed *Aedes aegypti* eggs. The adults ate an average of 15 eggs in one and one-half hours taking from 6 to 10 minutes to suck out the contents of a single egg. The mosquito egg was grasped by the long fore legs of the mite, pulled crosswise, firmly grasped by the cant-hook like claws of the pedipalps and held firmly in place from the rear by the second pair of legs. The sharp pointed chelicerae were then pushed into the egg, being inserted approximately half their length. The egg was usually pierced at about the middle, and when sucked out was often pierced at either end to completely empty the egg. From a side view using transmitted light, the contents of the egg may be observed passing into the adult as it greatly contracts and expands its abdomen and cephalothorax while sucking.

The optimum number of adults per rearing jar was found to be about 30 to 50, but larger numbers may be used. Individual jars have been maintained for six months without excessive losses of adults when properly cared for.

Egg laying: The problem of obtaining egg production was quite difficult at first and only a few eggs were observed when rearing *E. batatas* and *T. alleei* in Panama. Following the results of Melvin (1946), some cultures were placed in a temperature chamber at 35° C. for nearly two days, but this resulted in 100% mortality of the adults and no egg laying.

In the United States, experiments were carried on in which the temperature, relative humidity, and light were varied, and it was found that a temperature range from 27° to 34°, averaging 30° C., produced the best egg laying results. Exposure to 0° C. for several days did not stop egg laying, but at temperatues above 35° C. the production was greatly reduced. The humidity was kept above 85% and the substrate was quite moist. Variation of light in the present experiments did not produce noticeable effects in egg production.

Little has been known about egg production in chiggers, and most of the reports have been contradictory. In the present colonies, egg laying has been observed for a period of one year for *E. masoni*, and ten months for *E. alfreddugesi*.

The eggs were laid singly on the surface or in the interstices of the soil. The average number of eggs laid per day in the month of September was about 10 per female. The maximum observed was 20 eggs per female per day. Previous reports that females contained a maximum of only one egg when mounted on a slide were probably due to the destruction of the immature eggs by clearing agents. Individual females have laid eggs for periods of over six months. A very definite ovulation cycle has been observed in the egg and larval production by reared adults. Adult females only seven days of age have produced eggs which developed into larvae thirteen days later.

Transfer of second generation larvae to host: The newly hatched second, or later generations of unfed larvae were transferred to the

turtle host by suspending the turtle over the opened rearing jar as shown in Plate III. This method takes advantage of the postive phototaxis geotropism of the larvae and their increased activity at higher temperatures. The larvae crawled rapidly up the rearing jar onto the turtle (or caged snake) and attached after several minutes. Shaking or blowing in the jar, and varying the light intensity stimulated larval activity. This method has worked well when the rearing jar was braced in the center of an open bell jar which had a vaseline ring on the inner lip to prevent any chiggers from escaping. On some turtles, nearly 100% of the larvae attached and engorged. This arrangement was found to be superior to placing the rearing jar on a metal saddle above the turtle, since the larvae would not migrate down the outside of the rearing jar onto the turtle.

When transferring small numbers of larvae, or when making accurate counts of the emergences, a hand method worked quite well. The larvae were picked from the rearing jar by means of a moistened strip of paper held in forceps. The larvae were transferred to a droplet of water on the back of the host turtle or snake so as to wash off the larvae from the paper onto the host animal. To prevent escapes, the opened rearing jar was placed inside a ring of water or vaseline on a dark surface and stray larvae were recaptured.

Individual turtles were found to vary greatly in their attractiveness or susceptibility to chigger attachments. A few turtles were always 100% susceptible to the chiggers, while other turtles showed a variation of susceptibility at different times, especially in the evening when attachments were at a minimum. This problem deserves further study. Snakes were found to be more attractive hosts to the chigger larvae.

After the larvae had been transferred to the hosts, the turtles or snakes were replaced in the cages and the engorged larvae were collected in the rearing jars beneath the collecting funnels as before and the whole rearing procedure repeated.

DISCUSSION

Using the laboratory methods and materials described above, four generations have been reared of the chiggers which affect human beings in the United States: ***Eutrombicula alfreddugesi***, and ***E. masoni***. ***E. batatas*** (=***hominis***?) has been reared into the second generation. The methods have been duplicated several times using chiggers from different sources, and adults have been reared under natural and controlled temperature conditions. Sufficient numbers of reared larvae have been produced to permit experimental studies and limited acaricide tests to be carried on. The reproductive potential of chiggers is quite high; one culture of 23 females produced over 6,000 second generation larvae in two months.

Approximately 3,500 first generation adults and 2,500 second generation adults have been reared through their complete life histories with an efficiency of about 70%, (excluding those lost during experimentation).

Further details of the exact daily emergences and the numbers of each stage will be presented in a separate report along with the results

of studies on certain phases of the ecology, distribution, taxonomy and physiology of these species of chiggers.

The minimum time required to develop through a single generation and through each stage in the present cultures is summarized in the following table. The time required for second and later generations is approximately the same as for the first generation.

TABLE I

LENGTH OF TIME REQUIRED FOR CHIGGER DEVELOPMENT
(Minimum time)

STAGE	*E. masoni*	*E. alfreddugesi*	*E. batatas*
	Days	*Days*	*Days*
Egg	6	6	5
Deutovum	7	7	7
Larva (unfed)	1	1	1
feeding on host)	3	3	4
(fed)	2	2	2
Nymphochrysalis	6	6	6
Nymph	9	11	15
Imagochrysalis	6	7	6
Adult	10	12	25
Total	50	55	71

This laboratory method of rearing chiggers can be recommended with a minor reservation. It has been tested throughout a whole year and on the three species of chiggers affecting human beings in the United States. A disadvantage of this method is that rather large quantities of mosquito eggs are required, and no easily obtained substitute food has been discovered in the present project to date.

ACKNOWLEDGMENTS

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Thanks are due to Colonel John R. Wood, M. C., and Dr. Leigh E. Chadwick, Medical Division, Edgewood Arsenal, Md., for initiating and directing the study. Dr. Herbert C. Clark, Director of Gorgas Memorial Laboratory, Panama City, R. de P., and the AAF Committee on Aerial Dispersal of Insecticides, OAAB, Orlando, Florida, provided excellent laboratory facilities for the work. The staff of the U.S.D.A. Bureau of Entomology Laboratory, Orlando, Florida, gave assistance and provided the quantities of mosquito eggs. Encouragement and suggestions were kindly given by Drs. V. G. Dethier, H. E. Ewing, C. D. Michener, F. M. Snyder, and G. W. Wharton.

LITERATURE CITED

Blake, F. G., K. F. Maxcy, J. F. Sadusk, G. M. Kohls, and **E. J. Bell.** 1945. Studies on tsutsugamushi disease (scrub typhus, mite borne typhus) in New Guinea and adjacent islands: Epidemiology, clinical observations and etiology in the Dobadura area. Amer. Jour. Hyg., vol. 41, pp. 243–373.

Ewing, H. E. 1944. The trombiculid mites (chigger mites) and their relation to disease. Jour. Parasit., vol. 30, pp. 339–365, 8 figs.

Jenkins, D. W. 1946. The experimental rearing of chiggers under laboratory conditions. CWS Quarterly Progress Report on Insect and Rodent Control, vol. 10, pp. 34–38.

Kitashima, T., and **Miyajima.** 1918. Studien ueber die Tsutsugamushi-krankheit. Kitasato Arch. Exper. Med., vol. 2, pp. 91–146, 147–244.

Melvin, Roy. 1946. A note on the culturing of chiggers (Trombiculidae). Ann. Ent. Soc. Am., vol. 39, pp. 143–144.

Michener, C. D. 1946a. Observations on the habits and life history of a chigger mite *Eutrombicula batatas* (Acarina: Trombiculinae). Ann. Ent. Soc. Amer., vol. 39, pp. 101–118, pls. I-V.

1946b. A method of rearing chigger mites (Acarina, Trombiculinae). Amer. Jour. Trop. Med., vol. 26, pp. 251–256.

Miyajima, M., and **T. Okumura.** 1917. On the life cycle of the "akamushi," carrier of Nippon river fever. Kitasato Arch. Exper. Med., vol. 1, pp. 1–15, pls. I–III.

Nagayo, M., Y. Miyagawa, T. Mitamura, A. Imamura. 1917. On the nymph and prosopon of the tsutsugamushi, *Leptotrombidium akamushi*, n. sp. (*Trombidium akamushi* Brumpt), carrier of the tsutsugamushi disease. Jour. Exper. Med., vol. 25, pp. 255–272, pls. 24–27.

Wharton, G. W. 1946. Observations on *Ascoschongastia indica* (Hirst 1915) (Acarinida: Trombiculidae). Ecol. Monog., vol. 16, pp. 151–184.

Wharton, G. W., and **R. K. Carver.** 1946. Food of nymphs and adults of *Neoschongastia indica* (Hirst). Science, vol. 104, pp. 76–77.

THE NORTH AMERICAN CLEAR-WING MOTHS OF THE FAMILY AEGERIIDAE, by GEORGE P. ENGELHARDT. United States National Museum. Bulletin 190, 222 pages, 32 plates (16 colored), 1946. Price 75 cents.

Beutenmuller's beautifully illustrated monograph of this family was for many years the only comprehensive treatment available. Since it is now forty-six years old the study of these interesting moths has necessitated reference to scattered literature and the publication of Engelhardt's revision will be a valuable aid to lepi dopterists. It is unfortunate that the author could not have lived to witness the consummation of his lifelong study of the group.

According to the foreword by Carl Heinrich the author had worked over the group with the late August Busck, who took over the preparation of the manuscript and completed it before his own death in 1944. This collaboration of a leading specialist on the family with a great authority on the taxonomy of the microlepidoptera is ample testimony to the soundness of the resulting classification. The inclusion of seven new genera, nineteen new species and twenty new subspecific names suggests that the family will not soon be subject to further changes.

The monograph is in the form that satisfies a taxonomist, with an ample introductory discussion of the characteristics of the family, keys to genera and species, ample descriptions and notes on distribution, data on the location of types and notes on habits and life history if available. The black and white plates include figures of wing venation and genitalia and the colored plates include one hundred figures of adults. While the colored figures are not of the highest quality they are very good and should be satisfactory for identification.—A. W. L.

A STUDY OF THE MIGRATORY HABITS OF SALT MARSH AND ANOPHELINE MOSQUITOES[1]

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In the initial field use of the Insecticidal Aerosol Generator (1946) developed at Columbia University it was found necessary, for the proper evaluation of the extent of more or less immediate mosquito adult kill obtained by the DDT aerosol projected from the generator, to study the migratory habits of the natural mosquito population in the particular test area chosen.

The daily migratory habits of the salt marsh species, *Aedes sollicitans* and *Aedes taeniorhynchus*, were determined by making landing rate measurements, the number of mosquitoes landing per minute, in various locations in and about an open marsh land at Sykes Creek, near Cocoa, Florida, at various times of the day over a 24-hour period. The counts were made over complete body of personnel after remaining stationary for one minute. The following typical locations were chosen:

(a) Laurel tree (good canopy) on a road leading to the creek.
(b) Palm tree (fair canopy) on the same road.
(c) Middle of bridge crossing the creek (exemplifying completely open conditions).
(d) Laurel tree (good canopy), on the marsh land, located near edge of creek but dry under the tree.
(e) Open pickle weed grounds on the marsh land.
(f) Mangrove tree (fair canopy), on the marsh land, water under it.

The results are tabulated in Table I and the landing rate measurements obtained under the canopy of the laurel tree at the creek's edge and on the open pickle weed marsh are graphically represented in figure 1.

These counts made over a 24-hour period show:

(a) At about dawn, migration starts from open areas into shaded areas in or about the open marshes. This migration occurs over a period of at least one hour and the minimum count in the open marshes is obtained at about 8:00 A. M. and then shows a measureable increase in the hot sun of the late afternoon.

(b) At about dusk, full migration starts from shaded areas into the open marshes.

(c) Dawn flights decrease the mosquito population in the open marshes but do not reduce the counts to zero. Fairly high counts are obtainable in the open marshes even under bright sunlight.

[1]This paper is based on work done for the Office of Scientific Research and Development under O.S.R.D. contract OEMsr 1388 with Columbia University, Prof. Victor K. LaMer, Contract Director.

TABLE I

LANDING RATE MEASUREMENTS (NUMBER OF MOSQUITOES LANDING PER MINUTE) AS A FUNCTION OF TIME. SALT MARSH MOSQUITOES; COUNT MADE OVER FRONT AND BACK OF PERSONNEL

Location	Laurel on Road	Palm on Road	Bridge	Laurel, Creek Edge		Pickleweed		Mangrove	
				Outside Canopy	Under Canopy				
7–13–44 7:30 P. M.	100†	50†							
8:00	15	10	1	17	43 35	16	8	2	
8:15	45	10	0		20 15				
8:30 Sundown 8:35	45	10	0	9	16	10 18	10		
8:40								27	12†
8:45 Dusk				23	20		30†		
8:50	85††	25	0				40†	70†	70†
8:55							60†††*		
9:00 Twilight				45†††	19		40†††*	80†	50†
9:10	100†	20	0	80†††	8		60†††*		
9:15								100†	70††
9:30 Dark	80	7		50	15			35††	25††
9:36 P. M.								57††	35††
7–14–44 5:15 A. M., Dark	60†††	20	18						
5:25					28 18	48	63	55††	75††
5:35, Crack of Dawn	75†††	25	45		35 32	48	53	60††	75††
6:00, Dawn	70†††	50	30		19 25	100†	100†	120††	120††
6:07								150††	150††
6:15	60†	100	10						
6:30, Sunrise behind Clouds	100†††	150†	5		100†† 100††	90	85	165††	170††
6:45	200††	100	0		200†††200†††	78	62	255††	225††
7:00, Sun 5–10° above Horizon	200††	150	0					200††	190††
7:06					200†††200†††	33	28		
7:15	200††	150	0					170††	180††
7:30	200††	150	0	200†††	200†††	21	22	110†††100†††	
7:45	200††	150	0	200†††	200†††	10†	9†	60†††100†††	
10:30, Bright Sun	250†	150	0	200†††	200†††	17	19	125†	120†
4:45 P. M.	250†	40	0						
5:00 P. M.	125	30	2		200† 200†	44	50	125†	150†

Wind Speed:
7:30 P. M. period—2–4 mi. per hr.
5:15 A. M. period—1½ mi. per hour.

*These counts included only the shirt. Count more likely in neighborhood of 100.
†Indicates many also flying about.

(d) Greatly increased activity of mosquitoes in the open marshes was noticed before dawn and just after dusk. This was evidenced by loud humming and by large numbers of mosquitoes in the flashlight beam. This is further evidence of dawn and dusk migration.

(e) No definite data is obtainable on the long range migrations into nearby towns and other populated areas. Probably some of the

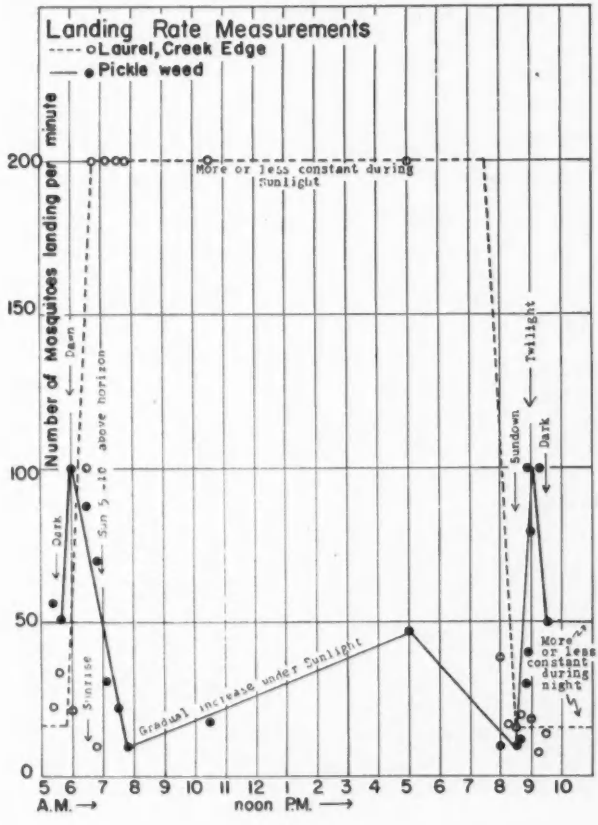

Figure 1

mosquitoes migrating out of the open marsh in the early morning continue to fly toward the towns during favorable hours and do not return until ready to lay eggs.

Hence it may be concluded:

(1) That a complete reduction of the landing rate to zero when obtained in an open marsh after treatment by a DDT aerosol over the dawn period may be attributed to the effectiveness of the aerosol. A

certain fraction of the reduction may also be attributed to the migratory habits of salt marsh mosquitoes.

(2) That a mangrove tree count of zero at 8:30 A. M. obtained after a dawn treatment represents kill and not migration.

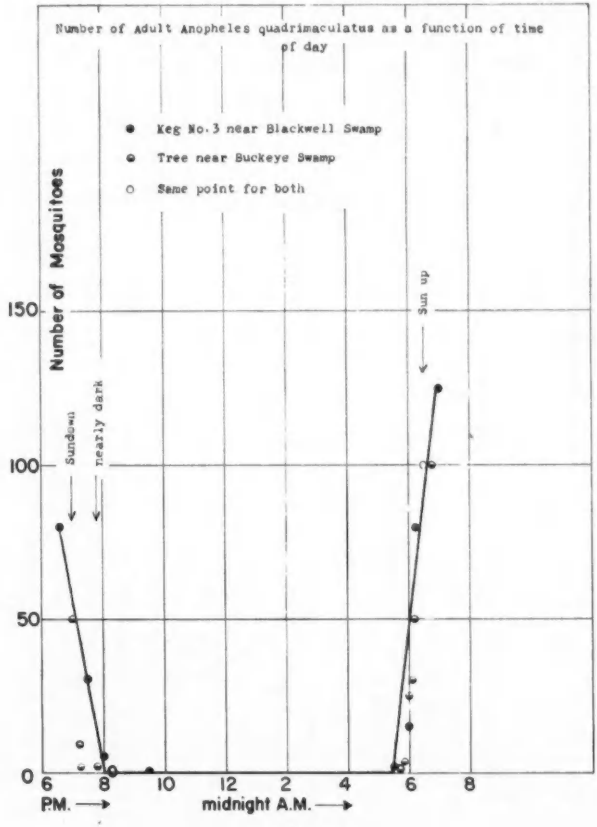

Figure 2

(3) That for practical control, the open marshes should be treated in the "predawn" period and the woods or forested areas after dawn as long as good meteorological conditions can be obtained.

It should be emphasized that although the population is comparatively low in the open marshes under sunlight, it is not zero. The tabulated results show that fairly high counts are obtainable in the open

marshes even under bright sunlight. In addition, when on several occasions the open marsh area was being inspected under bright sunlight for larvae pools, mosquito biting rates were annoyingly positive.

On the other hand, a study of the migratory habits of the *Anopheles quadrimaculatus* in several test areas of Buckeye and Blackwell Swamps (near Decatur, Ala.), showed that this species is completely inactive during periods of sunlight. While standing very close to a barrel or a tree hole containing such adults under conditions of sunlight, they have no tendency to land or bite. If a barrel is shaken, the adults leave the barrel and about 25% of them return within a half-hour. The results of the migratory habits are recorded in Tables II and III and two

TABLE II

BLACKWELL SWAMP (DECATUR, ALABAMA). NUMBER OF ANOPHELINE ADULTS IN RESTING PLACES

Time	Number of Adults in Kegs			Number of Adults in a Tree Hole	Remarks
	#1	#2	#3		
August 18: 6:35 P. M.	200	500	80	30–50	
6:50				37	Sundown.
7:30		200	30	17	
7:45				13	Nearly dark
8:00	4	19	5		
8:15		21	0	3	
9:30	4	18	1		
August 18–19: 9:30 P. M.–5:30 A. M.	4	18–16	1–4		Becoming light at 5:30 A. M.
6:00	81	32	15	6	
6:15		150	80	26	Fully light
6:30	125	200	100	29	Sun up
7:00		275	125		

typical cases are graphically represented in fig. 2. Between sunrise and dark, this species rests in some dark, cool, damp place such as a tree hole, hollow log, or empty keg. During the hour or so following sunset, they leave their resting places.

The results show it is possible to effect control of the adult by aerosol treatment (1946)

(1) during the day while they are resting in their tree holes,

(2) at dusk over the time they are leaving their tree holes,

(3) in the early morning over the time they are returning to their tree holes.

As previously mentioned, the anopheline adult is completely inactive during resting periods. The data in Table III show that the adults

TABLE III

BUCKEYE SWAMP (DECATUR, ALABAMA). NUMBER OF ANOPHELINE ADULTS IN RESTING PLACES

Time	Number of Adults in Kegs		Number of Adults Landing on Observer near Kegs	Number of Adults in a Tree Hole	Number of Adults	
					In Flight about Observer near Tree Hole	Landing on Observer near Tree Hole
August 18:	#1	#2				
7:00 P. M.	6	25	0	50	2	1
7:10				9	1	2
7:15	3	6		1	0	2
7:30	3		2			
7:45	1	1		0	1	1
8:10 P. M.	0	0	0	0	0	0
August 19:						
5:30 A. M.	0	0	0	0	3	1
5:50	0	0	0	3	10	2
6:00	0	0	1	25	20	5
6:07				30	20	4
6:10	0	0	2	50	15	3
6:18	1	5	2		5	2
6:30	5	8		100	1	1
6:40 A. M.	4	10	0	100	0	1

while in flight also have little tendency to bite observers located close to their resting places. The reluctance of these adults to bite in the vicinity of their resting places while in flight is substantiated by landing rate measurements made in the woods at a distance of 50 to 200 feet from the holes. At such points, the landing rate was practically zero for all times over the 24-hour period. From this data, it may be concluded that the anopheline adults inhabiting the woods about Buckeye and Blackwell swamps have, on the whole, acquired definite preferences, probably from habit, for specific locales in which blood meals are daily sought.

Although it is well known that mass migration of salt marsh species out of jungle areas occurs at dusk, nevertheless landing rates of over 100 have been obtained during the night in such areas.

The assistance of Lt. Comdr. George E. Bohart of Navy Medical Research Unit No. 2 and Dr. L. D. Anderson of the Department of Agriculture is gratefully acknowledged.

LITERATURE CITED

F. Brescia, V. K. LaMer et al. 1946. "Salt Marsh and Anopheline Mosquito Control by Ground Dispersal of DDT Aerosols." O.S.R.D. Report No. 5731.

IXODES BISHOPPI, A NEW SPECIES FROM GEORGIA (ACARINA: IXODIDAE)

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In the course of routine examinations of birds and mammals captured at Savannah, Ga., the authors collected numerous specimens of a new species of tick, *Ixodes bishoppi*. The species is related to *I. minor* Neum. and *I. muris* Bishopp and Smith, and has similar host relationships. The larvae and nymphs were fairly common on cotton rats, *Sigmodon hispidus hispidus* Say and Ord., and were occasionally found on birds. Of 56 cotton rats examined 40 were infested, carrying a total of 191 larvae and 40 nymphs. Of numerous birds of various species examined 3 were infested; a house wren, *Troglodytes aëdon aëdon* (Vieill.), with 5 larvae and 1 nymph, a house wren with 8 larvae, and a towhee, *Pipilo erythrophthalmus erythrophthalmus* (Linn.), with 6 larvae and 2 nymphs. One of several house mice, *Mus musculus musculus* Linn., caught in a grassy field was infested with 2 larvae. Of 13 cottontail rabbits, *Sylvilagus floridanus* ssp., only 1 was infested, carrying a single nymph. Adult ticks were collected only twice, in each instance from a cotton rat. One rat was infested with 1 male and 7 females, the other with a single female. Numerous males and females, including the types, were reared from specimens collected as larvae or nymphs.

Ixodes bishoppi n. sp.

Female (Plate I, *A*, *B*, and *C*).—Capitulum, length 771 μ (from tip of hypostome to line drawn between tips of posterior lateral angles of basis capituli); basis capituli, width 393 μ, reddish brown, posterior margin slightly concave, posterior lateral angles prominent and rounded, porose areas shallow, almost reaching posterior margin of basis capituli, roughly ovoid, their width (87 μ) about equal to the interval between them; ventrally with long, pointed auriculae that project ventrally and posteriorly from the basis capituli and curve slightly mediad. Palpi long and slender (length 626 μ), article II distinctly longer (320 μ) than article III (233 μ), article I with a long, sharp spine ventrally. Hypostome long, slender, sides tapering from the apical fourth to a sharply rounded tip; 4 rows of teeth on each side near the tip, followed by 3 rows near the center and 2 rows near the base; about 5 teeth in inner row, 7 teeth in next row, and 10 in each of the 2 outer rows, with additional small teeth at the apex not aligned with any row.

Scutum, length 1,260 μ, witdh 840 μ, broadest at the middle, tapering behind the middle, posterior margin rounded; reddish brown, coarsely punctate, punctations most numerous on posterior third, a few short pale hairs; cervical angles moderately long, broadly pointed; cervical grooves shallow, widely divergent posteriorly, reaching almost to the margin of the scutum near the posterior third; lateral carinae short, faint.

Legs brown, slender, all tarsi abruptly tapered near the tip, this especially pronounced in tarsus I; tarsus I almost twice (480 μ) as long as metatarsus I (262 μ). Coxae separated by a narrow interval (in unfed specimen); coxa I with a long, sharply pointed, internal spur; a short external spur on all coxae, longest on coxa II.

Stigmal plates of moderate size (233 x 204 μ), broadly oval, the long axis transverse to the body axis; macula nearly circular, located near anterior margin.

Body light brown, a few punctations and short pale hairs, the hairs longer and more numerous on the marginal fold; marginal groove deep, extending from shield around posterior margin; genital grooves divergent, reaching posterior margin of body; vulva between coxae IV; anal groove rounded in front, converging behind anus, reaching posterior margin of body.

Eleven other females, reared from nymphs or larvae from various lots, showed the following variations in dimensions (maximum, minimum, and average respectively): length of capitulum—870 μ, 780 μ, 828 μ; width of basis capituli—480 μ, 390 μ, 429 μ; length of palp—720 μ, 630 μ, 660 μ; length of palpal article II—390 μ, 330 μ, 354 μ; length of palpal article III—240 μ, 210 μ, 228 μ; length of scutum—1,440 μ, 1,320 μ, 1,392 μ; width of scutum—990 μ, 900 μ, 909 μ; length of tarsus I—540 μ. 480 μ, 534 μ; length of metatarsus I—300 μ, 240 μ, 249 μ. In some females the porose areas are circular and in some, tarsus I is more than twice as long as metatarsus I.

Male (Plate II, *A*, *B*, and *C*).—Capitulum, length 466 μ; basis capituli dark reddish brown, width 276 μ, widest behind base of palpi, narrowed posteriorly, posterior margin faintly convex, posterior lateral angles long and pointed; ventrally with sharp, triangular auriculae, posterior margin convex. Hypostome notched at the tip, armed on each side with a row of serrate plates and one row of teeth. Palpi short, 320 μ long, article II, 160 μ long, article III, 116 μ long, article I protruding ventrally as a short, broad, 3-sided tooth.

Scutum reddish brown, length 1,339 μ, width 698 μ, pseudoscutum distinguishable, darker and more convex than rest of scutum, coarsely and closely punctate, punctations most numerous near the center, a few short hairs; cervical grooves distinct, converging then diverging, not reaching the margin of scutum; cervical angles rounded.

Legs light brown, tarsi abruptly tapering as in the female, tarsus I, 364 μ long, metatarsus I 160 μ long; coxae not contiguous, coxa I with a short slender internal spur, all coxae with short, broad, external spurs, shortest on coxa I.

Stigmal plates of moderate size, 218 x 160 μ, oval, the long axis parallel to the body axis; macula circular, located near ventral margin.

Body, marginal fold wide, light brown, with a few pale hairs; marginal groove deep, reaching the margin at the anterior sixth; venter

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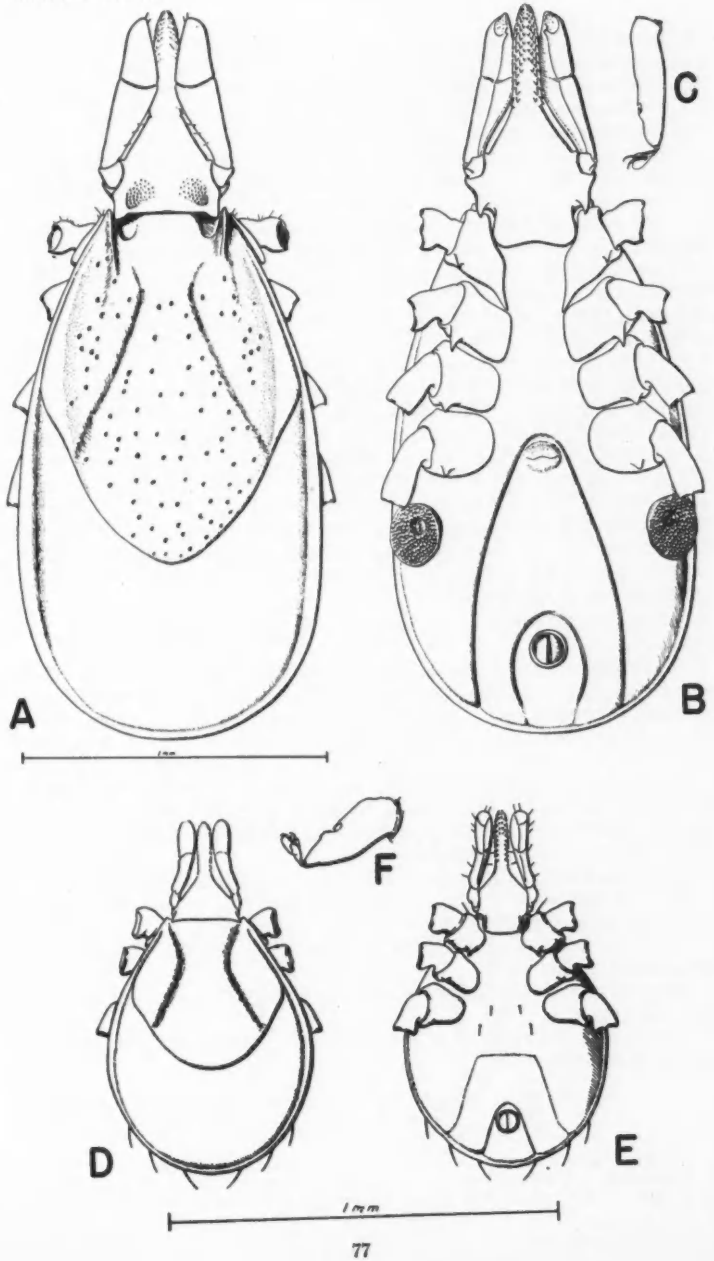
EXPLANATION OF PLATE I

Ixodes bishoppi n. sp. *A*, Dorsal view of female. *B*, Ventral view of female. *C*, Lateral view of tarsus I of female. *D*, Dorsal view of larva. *E*, Ventral view of larva. *F*, Lateral view of tarsus I of larva. Drawn by Arthur Cushman.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brown, with scattered punctations and pale hairs. Pregenital plate 218 μ long, 131 μ wide, tapering anteriorly; median plate 553 μ long, 407 μ wide at widest part, anterior margin gently concave, sides gradually diverging to posterior sixth then sharply converging, posterior margin rounded; adanal plate 320 μ long, 204 μ wide at anterior end, tapering to posterior margin; anal plate 306 μ long, 218 μ wide, anterior margin narrowly rounded, posterior margin broadly rounded, anal groove as in the female.

Ten other males, reared from nymphs or larvae from various lots, showed the following variations in dimensions (maximum, minimum, and average respectively): length of capitulum—495 μ, 436 μ, 477 μ; width of basis capituli—306 μ, 276 μ, 289 μ; length of palp—349 μ, 292 μ, 330 μ; length of palpal article II—175 μ, 146 μ, 158 μ; length of palpal article III—146 μ, 116 μ, 138 μ; length of scutum—1,470 μ, 1,410 μ, 1,428 μ; width of scutum—750 μ, 690 μ, 729 μ; length of tarsus I—422 μ, 348 μ, 388 μ; length of metatarsus I—204 μ, 189 μ, 192 μ; length of pregenital plate—292 μ, 233 μ, 262 μ; width of pregenital plate—218 μ, 146 μ, 180 μ; length of median plate—640 μ, 567 μ, 606 μ; width of median plate—480 μ, 407 μ, 448 μ; length of adanal plate—364 μ, 292 μ, 312 μ; width of adanal plate—233 μ, 189 μ, 199 μ; length of anal plate—320 μ, 276 μ, 284 μ; width of anal plate—292 μ, 218 μ, 254 μ. In some males the pregenital plate is incomplete at the apex, forming an irregular notch. A number of males bear two small collections of pits near the posterior margin of the basis capituli corresponding to the porose areas of the female.

Nymph (Plate II, *D*, *E*, and *F*).—Similar to female, light brown in color.

Capitulum, length 364 μ; basis capituli, width 218 μ, posterior margin slightly convex, posterior lateral angles prominent, bluntly pointed; ventrally with prominent auriculae projecting posteriorly and ventrally, ventral posterior margin straight, without cornua or tubercles. Palpi long and slender (length 320 μ), articles II and III of equal length (146 μ), article I with a prominent, sharp tooth projecting ventrally and somewhat laterally. Hypostome long and slender, pointed, 3 rows of teeth on each side, 6 teeth in inner rows, 9 in each of the outer 4 rows, with additional small teeth at the tip.

Scutum, length 567 μ, width 466 μ, widest near the middle, posterior margin broadly and evenly rounded; cervical grooves as in the female; a few scattered punctures.

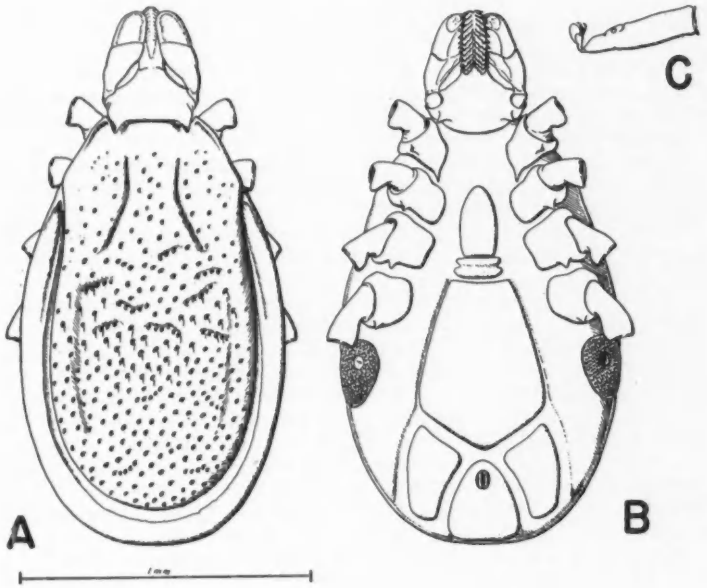
Legs, coxae, and tarsi similar to those of the female; tarsus I, 276 μ, metatarsus I, 131 μ.

Stigmal plates 109 μ dorsoventrally, 95 μ anteroposteriorly, macula near the center.

Body light brown, with a few pale hairs, marginal groove deep, anal groove as in the female.

EXPLANATION OF PLATE II

Ixodes bishoppi n. sp. *A*, Dorsal view of male. *B*, Ventral view of male. *C*, Lateral view of tarsus I of male. *D*, Dorsal view of nymph. *E*, Ventral view of nymph. *F*, Lateral view of tarsus I of nymph. Drawn by Arthur Cushman.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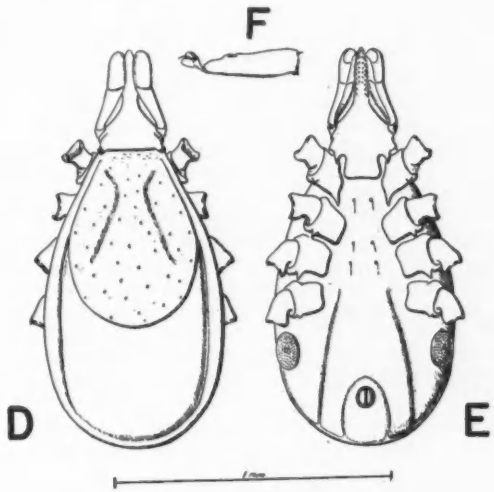
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Larva (Plate I, *D*, *E*, and *F*).—Capitulum light brown, length 233 μ; basis capituli, width 146 μ, posterior margin straight, posterior lateral angles acute, slightly salient posterolaterally; ventrally with triangular auriculae projectiug posterolaterally; posterior margin rounded, without cornua or tubercles. Palpi long and slender (length 175 μ), articles II and III of equal length (80 μ, article I prominent ventrally. Hypostome with 3 rows of teeth on each side, 5 teeth in inner row, 9 teeth in outer rows.

Scutum, length 335 μ, width 378 μ, posterior margin broadly rounded. Cervical grooves shallow, narrow, converging then diverging, reaching the posterior margin of the scutum.

Tarsus I, 189 μ, metatarsus I, 87 μ, tarsi tapering more gradually than in the nymph. A long internal spur on coxa I, short external spurs on coxae I and II.

Body yellowish brown with a few pale hairs around the margin. Anal groove faint, less convergent posteriorly than in the female.

Type.—No. 1519, U. S. National Museum, holotype female, allotype male, paratype male and female from Accession No. 17494, Dec. 24, 1943, Savannah, Ga., on cotton rat (collected as larvae and reared to adults.) Nymph and larva described from specimens reared from a female from Accession No. 17455, Oct. 7, 1943, Savannah, Ga., on cotton rat. Other paratypes deposited in the U. S. National Museum, as follows: 8 nymphs, 2 males, 2 females from Accession No. 17450, Sept. 22, 1943, Savannah, Ga., on cotton rat (collected as larvae); 1 female, No. 17453, Sept. 21, 1943, Savannah, Ga., on cotton rat; 1 male, 4 females (and many larvae and nymphs reared from one of the females), No. 17455, Oct. 7, 1943, Savannah, Ga., on cotton rat; 1 nymph, 1 male, 2 females, No. 17458, Oct. 13, 1943, Savannah, Ga., on cotton rat (collected as larvae); 2 males, 1 female, No. 17464, Nov. 20, 1943, Savannah, Ga., on house wren (collected as larvae); 1 female, No. 17471, Dec. 3, 1943, Savannah, Ga., on cotton rat (collected as nymph); 1 female, No. 17476, Dec. 14, 1943, Savannah, Ga., on cotton rat (collected as nymph); 1 female, No. 17495, Jan. 1, 1944, Savannah, Ga., on cotton rat (collected as larva); 1 nymph, 1 male, 1 female, No. 17516, Jan. 25, 1944, Savannah, Ga., on cotton rat (collected as nymphs); 2 females, No. 17531, March 13, 1944, Savannah, Ga., on cotton rat (collected as nymphs); 2 nymphs, 1 male, No. 32017, Jan. 16, 1943, Savannah, Ga., on cotton rat (collected as larvae and nymph); 1 male, 2 females, No. 32020, Jan. 23, 1943, Savannah, Ga., on cotton rat (collected as nymphs); 1 nymph, 1 male, No. 32022, Jan. 26, 1943, Savannah, Ga., on house mouse (collected as larvae); 1 larva, 1 male, No. 32023, Jan. 26, 1943, Savannah, Ga., on cotton rat (collected as larva and nymph); 6 nymphs, 1 male, 1 female, No. 32026, Feb. 2, 1943, Savannah, Ga., on towhee (collected as larvae and nymphs); 1 male, 2 females, No. 32079, April 4, 1943, Savannah, Ga., on cotton rat (collected as nymphs).

This species is most closely related to *Ixodes minor* which is recorded from *Hesperomys* sp. (*Peromyscus:* Muridae) in Guatemala. Other species of similar appearance are *I. dentatus* Neum., *I. muris*, *I. diversifossus* Neum., *I. spinipalpis* (Hadwen and Nuttall), *I. neotomae* Cooley, *I. peromysci* Augustson, and, in the immature stages, *I. scapularis* Say.

The female differs from that of *I. minor* in the tapering scutum, the anal grooves converging behind the anus, and the long ventral spine on palpal article I. It differs from *I. muris* in these same characteristics, and also in the ventrally projecting auriculae. It differs from *I. diversifossus* and *I. dentatus* in the longer and more tapering scutum, longer and more tapering basis capituli, less prominent lateral carinae, and the shorter internal spur on coxa I. It differs from *I. spinipalpis* in the longer and more tapering basis capituli, less prominent lateral carinae, and larger coxal spurs. It differs from *I. neotomae* and *I. peromysci* in the greater number of goblets on the stigmal plates and the shorter, less prominent lateral carinae. In the recent monograph of the Genus *Ixodes* by Cooley and Kohls (1945) this species would key to *I. neotomae*.

The male differs from that of *I. minor* in the notched hypostome, the relatively shorter basis capituli, palpal article II distinctly longer than article III, the presence of distinct auriculae, the position of the coxal spurs at the external angles of the coxae, and the wide marginal fold. It differs from *I. muris* in the presence of long cornua, prominent auriculae, curved ventral posterior margin of basis capituli, shorter adanal plates, narrower median plate, and larger external spur on coxa I. It differs from *I. dentatus* and *I. diversifossus* in the absence of internal spurs or tubercles on coxae II and III, the narrower median plate, and the anteriorly tapering pregenital plate. It differs from *I. neotomae* and *I. peromysci* in having more numerous and larger punctations on the scutum, more goblets on the stigmal plates, and more teeth on the hypostome. In Cooley and Kohls (1945) the male of this species keys to item 7, beyond which it does not entirely agree with either branch of the key.

The nymph differs from that of *I. muris* in the spine on palpal article I, and the anal groove converging behind the anus; from *I. dentatus* in the longer scutum, prominent auriculae, shorter internal spur on coxa I and longer cornua; from *I. spinipalpis* in the more sharply tapering auriculae, absence of lateral carinae, and converging anal groove; and from *I. scapularis* in the absence of ventral cornua, the auriculae broader and not projecting ventrally, more abruptly tapering tarsus I, and converging anal groove. The nymph of *I. minor* is unknown.

It differs from *I. neotomae* and *I. peromysci* in having more goblets on the stigmal plate and in the absence of lateral carinae.

The larva differs from that of *I. muris* in the absence of cornua and in the greater relative length of the capitulum; from *I. dentatus* in the pointed auriculae and the narrow cervical grooves; from *I. spinipalpis* in the greater relative length of the capitulum; and from *I. scapularis* in the absence of ventral cornua and the auriculae broader and not projecting ventrally. The larva of *I. minor* is unknown.

The authors take pleasure in naming the species in honor of F. C. Bishopp, in recognition of his contributions to our knowledge of the Ixodoidea.

LITERATURE CITED

Cooley, R. A., and **Glen M. Kohls.** 1945. The genus *Ixodes* in North America. U. S. Pub. Health Serv., Natl. Inst. Health Bul. 184, 246 pp., illus.

RESISTANCE OF MOSQUITO LARVAE AND PUPAE TO EXPERIMENTAL DROUGHT

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Random field observations of anopheline larve in temporary puddles in New Guinea first called the problem of drought resistance to our attention as one of possible importance in mosquito control operations. We noted that following periods of relative drought rain puddles which had evaporated to the damp mud stage and were subsequently reflooded often contained numerous anopheline larvae in the late stages of development. Although the larval cycle of mosquitoes in the tropics is greatly accelerated it is an *a priori* consideration that these larvae must have survived the temporary drought on the damp mud in order to be of such advanced development shortly after "dry" puddles were flooded by rains. Preliminary field laboratory observations in New Guinea showed that fourth instar larvae of *Anopheles punctulatus* could survive for approximately 120 hours on damp filter paper flooded for thirty minutes at twenty-four hour intervals.

While considerable attention has been given to the drought resistance of eggs of various species of *Aedes*, little of significance has been published concerning the resistance of mosquito larvae to drought. Celli and Casagrandi (1899) reported that *Anopheles* larvae could survive on moist mud for 96 hours. In preliminary experiments Schoof, Schell and Ashton (1945) found that larvae and pupae of *Anopheles quadrimaculatus* survived in muck for 48 hours and that the pupae were more resistant to these conditions than the larvae. Headlee (1945) stated that pupae of *Aedes sollicitans* survive for 24 hours in soft mud and half grown larvae for only a few hours.

By the experiments described below we have attempted to determine under controlled laboratory conditions the effects of varying periods of drought and of periodic flooding on the vitality of the larvae of three species of mosquitoes: *Anopheles walkeri*, a species more or less restricted to the shaded grassy margins of swamps and lakes; *Aedes vexans*, a temporary pool inhabitant; and, *Wyeomyia smithii*, a species restricted to the water held in pitcher plants (*Sarracenia purpurea*).

For these experiments larvae of *Wyeomyia smithii* were collected from pitcher plants in the Lloyd-Cornell Reservation at McLean, N. Y., on May 10; larvae and pupae of *Aedes vexans* from a temporary pool near Varna, N. Y., on May 20, and from small temporary puddles in Ellis Hollow Swamp, Ellis, N. Y., on May 24; and, larvae of *Anopheles walkeri* from Cayuta Lake swamp, near Cayutaville, N. Y., on June 14.

RESISTANCE TO CONTINUOUS DROUGHT

Series I. Aedes vexans, fourth instar larvae. Petri dishes were prepared by placing oversized filter paper in the bottom and adding sufficient water (2.5 cc.) to dampen the paper but yet allow no visible free water. Pond water from the sources of the collections was used

throughout. The experimental dishes were kept covered so that maximum humidity would prevail, but control dishes were left uncovered. Temperature in the laboratory ranged between 21° and 28° C.

Five larvae were added to each of 30 dishes and examined on the following schedule: 15 each after 24 and 48 hours, and 30 each after 72, 96, 120 and 144 hours of continuous drought. Six control dishes differed from the experimentals only in that they were flooded to a depth of about one-fourth inch and were examined every twenty-four hours.

The maximum survival time was 96 hours when 17 per cent had survived (Table I). At 48, 72 and 96 hours there was no significant difference in the per cent survival. Although the control group showed a daily decrease, the number surviving was always roughly at least twice as great as the experimentals.

TABLE I

RESISTANCE TO CONTINUOUS DROUGHT AND TO DROUGHT WITH PERIODIC REFLOODING

SERIES SPECIES	INSTAR	PER CENT SURVIVAL										
		Time Interval in Hours										
		24	48	72	96	120	144	168	192	216	240	264
I–Cl[1] vexans.....	4	87	70	47	30	30	30	27	....	....	....	....
I–Drt. "	"	80	13	17	17	0	....	....	....	....	....	....
I–Rfl "	"	80	7	0	....	....	....	....	....	....	....	....
II–Cl vexans.....	3	100	100	100	87	83	77	....	....	....	....	....
II–Drt "	"	90	37	43	17	20	....	....	....	....	....	....
II–Rfl "	"	90	67	50	30	17	7	....	....	....	....	....
III–Cl vexans.....	1 & 2	90	90	90	....	....	....	....	....	....	....	....
III–Drt "	"	....	36	....	....	....	....	....	....	....	....	....
IV–Cl smithii.....	4	100	100	92	83	75	42	42	33	33	....	....
IV–Drt "	"	....	83	....	58	....	48	....	83	....	....	....
IV–Rfl "	"	....	83	50	42	33	33	33	33	33	....	....
V–Cl walkeri.....	4	100	100	100	100	100	100	87	87	87	80	73
V–Drt "	"	100	73	80	67	27	0	....	....	....	....	....
V–Rfl "	"	73	73	67	60	53	40	33	13	7	7	0

[1]Cl=control group; Drt=continuous drought; Rfl=drought with periodic reflooding.

Series II. Aedes vexans, third instar larvae. The same number of larvae and dishes were used and set up as in Series I. Examination was on the following schedule: 30 larvae each after 24, 48, 72, 96 and 120 hours of continuous drought. Thirty control larvae were treated as in Series I.

The maximum observed survival time was 120 hours when the experiment was terminated (Table I). Survival of the intermediate time groups decreased irregularly to 20 per cent after 120 hours. The control series showed a slight daily decrease in the number of living larvae, nevertheless there was always a significant difference between them and the experimentals.

Series III. Aedes vexans, first and second instar larvae. One experimental dish of 14 larvae was examined after 48 hours of drought. A control dish of 10 larvae was treated as in Series I.

The maximum observed survival time was 48 hours, when the experiment was terminated (Table I). The 48 hour drought reduced survival to 36 per cent, approximately one-third that of the control group.

Series IV. Wyeomyia smithii, fourth instar larvae. Sixty larvae were set up as in Series I but with 12 to a dish, and examined on the following schedule: 12 each after 48, 96, 144 and 192 hours of continuous drought. A control dish of 12 larvae was treated as in Series I.

The maximum observed survival time was 192 hours when the experiment was terminated (Table I). Survival was strikingly irregular for the intermediate time groups. At 144 hours the per cent surviving in the experimental group was equal to that of the control, and at 192 hours only 33 per cent of the controls were living whereas 83 per cent of the experimental group had successfully resisted the eight days of drought.

TABLE II

SURVIVAL OF *A. walkeri* LARVAE FOLLOWING CONTINUOUS DROUGHT

NUMBER LARVAE USED	PER CENT SURVIVAL										
	Time Interval in Hours										
	24	48	72	96	120	144	168	192	216	240	264
10	100	100	100	100	100	90	70	70	70	70	70
15	.....	73	73	67	60	47	47	47	40	40	40
15	.....	.....	80	80	67	47	47	47	40	40	40
15	.....	.....	.....	67	53	53	47	40	33	20	20
15	.....	.....	.....	.....	27	13	7	7	0	.....	.....
15	.....	.....	.....	.....	0	.....	.....	.....	.....	.....	.....

Series V. Anopheles walkeri, fourth instar larvae. One hundred larvae were set up as in Series I and examined on the following schedule: 10 after 24 hours, and 15 each after 48, 72, 96, 120 and 144 hours of continuous drought. After examination the dishes were kept flooded to determine possible injury to the larvae caused by the drought Fifteen control larvae were treated as in Series I.

The maximum survival time was 120 hours (Table I). Mortality was quite limited up to 96 hours of drought and subsequent daily examination of these larvae indicated that drought had caused no significant injury. However, the 27 per cent which survived the maximum time were evidently injured and decreased to 7 per cent 48 hours after being returned to flooded conditions (Table II).

Probable causes of death. Microscopic examination of dead larvae was made during each period of observation and their apparent condition recorded. These observations showed that of all dead fourth instar *A. vexans* "larvae" (Series I) 58 per cent exhibited a humped thorax and/or pupal respiratory trumpets indicating that internal changes preliminary to pupation were well advanced. It seems that the cause

of death *per se* was not due solely to lack of free water but to a combination of this coincident with the internal changes preparatory to pupation. None successfully completed pupation.

Pupation was similarly critical for *W. smithii* (Series IV) but 66 per cent died as fully formed pupae which had been unable to completely free themselves of the fourth instar exuviae. That the larvae in the intermediate time groups were inadvertently older and reached the critical pre-pupation stage while subjected to drought may be taken as the probable explanation of the low survival recorded.

In contrast, no more than one per cent of the larvae of *A. walkeri* died as "prepupae." Apparently these individuals as a group were younger and scarcely any reached the critical pupation period during the experiment.

The molting process from third to fourth instar in *A. vexans* (Series II) was also critical, but at least three (two per cent) successfully accomplished this molt.

TABLE III

EMERGENCE OF *A. vexans* IMAGINES IN CONTINUOUS DROUGHT

NUMBER PUPAE USED	SEX	NUMBER IMAGINES EMERGING			TOTAL	PERCENT OF TOTAL
		Time Intervals in Hours				
		24	48	72		
.....	♂	16	56	1	73	.....
.....	♀	10	28	6	44	.....
125	.....	26	84	7	117	94

RESISTANCE TO DROUGHT AND PERIODIC FLOODING

Following the same general procedures groups of larvae from each series were subjected to drought broken at 24 hour intervals by a thirty minute period of flooding. Fifteen fourth instar *A. vexans*, 30 third instar *A. vexans*, 15 fourth instar *A. walkeri* and twelve fourth instar *W. smithii* larvae were used.

It seems apparent that periodic flooding was of no obvious benefit to *A. vexans* and *W. smithii* larvae in surviving the drought, but larvae of *A. walkeri* survived 120 hours longer than those in continuous drought (Table I).

Conditions of death prevailed as in continuous drought. We had thought that periodic flooding would in some degree simulate slight tidal or rainfall fluctuations which would assist larvae in withstanding drought. Either this was not the case or the flooding should have been of longer duration to be of survival value to the larvae.

On the other hand periodic flooding may possibly have been detrimental. It was observed that larvae of *A. vexans* and *W. smithii* secreted a thin mucous covering during continuous drought, while those subjected to periodic flooding did not renew this mucous after the first flooding. Possibly the protective mucous covering was dissolved and the larvae were incapable of renewing it so frequently. No mucous secretions were observed on *A. walkeri* larvae.

PUPAE

Series VI. Aedes vexans, pupae. One hundred and twenty-five pupae were set up as in Series I, the number in each dish depending upon the number available daily from the culture. Each dish was examined at 24 hour intervals and the number of imagines recorded. No control was used.

Imagines emerged from 94 per cent of the pupae. The maximum time of stranding was 72 hours, after which no emergences were recorded (Table III).

Pupae of the other species were not available.

DISCUSSION

Some degree of correlation between the resistance to drought and the typical natural microhabitat of these species was noted. Conditions seem to be more favorable for frequent periods of drought in the pitcher plant microhabitat of *W. smithii* than in the larger bodies of water inhabited by *A. vexans* and *A. walkeri*. It follows that survival in pitcher plants requires some measure of drought resistance. Our experiments strikingly bear this out in showing larvae of *W. smithii* to be much more resistant to drought than either *A. walkeri* or *A. vexans*.

Our observations showed clearly that pupae of *A. vexans* were more resistant to drought than the larvae. Of major significance is the fact that lack of free water did not prevent emergence of the imago.

The practical implications of these experiments to entomologists engaged in mosquito control are obvious. Larvicide programs should be extended to include all damp depressions which may hold water periodically for relatively short periods of time.

SUMMARY

1. Larvae of three species of mosquitoes (*A. vexans*, *W. smithii* and *A. walkeri*) were subjected to controlled drought in the laboratory.

2. The maximum survival time of *A. vexans* under continouus drought was determined to be 120 and 96 hours respectively for third and fourth instar larvae.

3. The maximum observed survival time of *W. smithii* larvae under continuous drought was 192 hours.

4. The maximum survival time of *A. walkeri* under continuous drought was 120 hours.

5. Periodic flooding for 30 minutes at 24 hour intervals was of no obvious benefit to *A. vexans* and *W. smithii* larvae in surviving drought, but considerably prolonged survival of *A. walkeri* larvae.

6. Imagines emerged from 94 per cent of *A. vexans* pupae under drought conditions.

7. Larvicide programs should include depressions in the damp mud stage which may subsequently be flooded.

REFERENCES

Celli, A., and **Casagrandi.** 1899. Per le distruzione delle zanzare, contributo allo studio sostanze zanzaricide. Roma. (*As quoted by* Stephens, J. W. W. and S. R. Christophers, 1904. The Practical Study of Malaria and Other Blood Parasites. London: Williams & Norgate, p. 81.)

Headlee, Thomas J. 1945. The Mosquitoes of New Jersey and Their Control. New Brunswick: Rutgers Univ. Press, p. 52.

Schoof, H. F., S. C. Schell and **D. F. Ashton.** 1945. Survival of anopheline larvae and pupae in muck. Jour. Econ. Ent., 38 (1): 113–114.

TAXONOMIC STUDIES ON THE EPHEMEROPTERA
IV. THE GENUS STENONEMA

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The genus *Stenonema* is abundant and ecologically widely distributed in North America east of the Rocky Mountains. The flattish nymphs of one or more species are to be found in most permanent bodies of water in which currents are set up either by wind action or by gravity. For a number of years I have been accumulating material for a generic revision. The taxonomy of the group is involved and it is apparent that considerable rearing of imagoes from their respective nymphs must be undertaken before some of the problems can be solved. *Stenonema* does, however, consist of three distinct complexes or groups of species. For two of these, i. e., *tripunctatum* and *interpunctatum*, enough data have been accumulated by various investigators as well as by the author that a rather clear picture can be presented at this time. The third complex, *pulchellum*, consists of numerous closely related species and subspecies and presents many puzzling questions. To solve the problems presented in the last named complex, imagoes must be reared from various parts of the geographical ranges of the sundry species, a type of investigation which proceeds slowly and demands the co-operation of numerous students of the ephemerids. I hope that this preliminary paper may stimulate such endeavors and that eventually we shall be able to compose a complete picture of the taxonomy of the group from its entire range. The present work is restricted to a general discussion and delimitation of the genus plus taxonomic revision of the *tripunctatum* and the *interpunctatum* complexes.

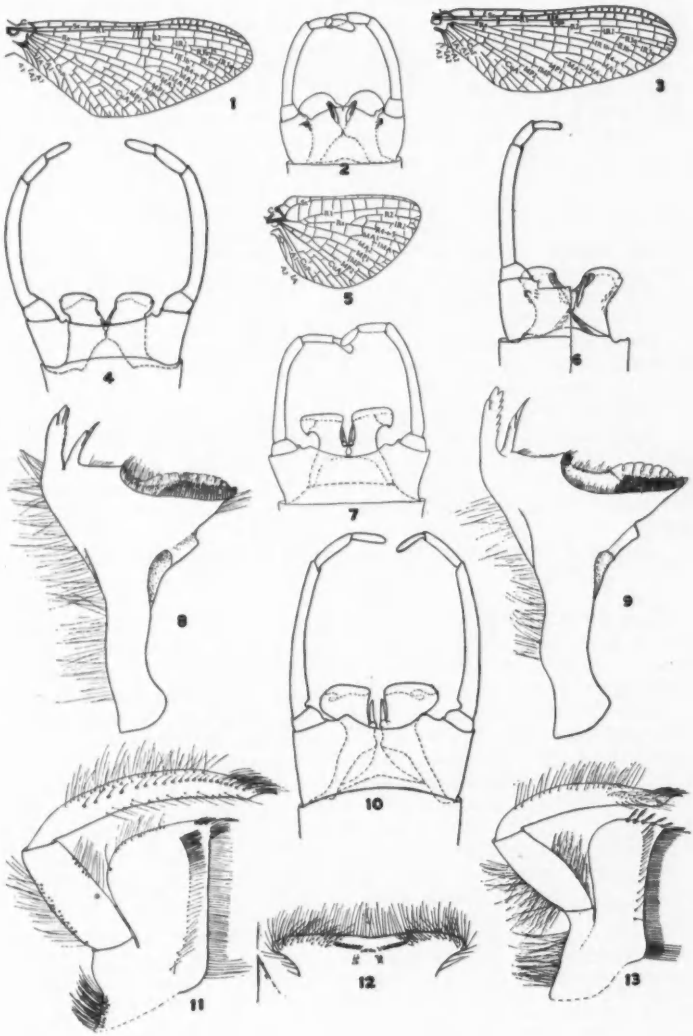
In preparation for this paper I have seen the collections and types for the genus which are deposited in the British Museum (Natural History) Collection, the Canadian National Collection, the Cornell University Collection, the Illinois Natural History Survey Collection, the Museum of Comparative Zoology Collection as well as those in the American Museum of Natural History Collection and, of course, in my own personal collection. I wish to thank the various officers and scholars of the above institutions for courtesies extended to me. Special thanks are due the American Museum of Natural History, and particularly the late Dr. Frank E. Lutz, for research facilities. Dr. Mont A. Cazier suggested the utilization of the statistical techniques that have been applied to the interpunctatum complex. His aid and advice, as well as that of Miss Annette Bacon, have been invaluable. Any errors in the use of these techniques or of interpretation should, however, be charged solely to the author. Finally, I should like to say that detailed distributional records have not been given at this time for two reasons: (1) Because they are as yet incomplete, and (2) in order to save printing space. I do, however, have detailed records of emergence dates, localities, etc., in note form.

Genus **Stenonema** Traver

Imago.—Compound eyes of male moderately large; separated dorsally by about the diameter of a laterally situated ocellus; eye of female flattened and separated by distance greater than diameter of eye; the posterior margin of the female head weakly excavated. Pronotum strongly excavated posteromedially; lateral lobes reflexed. Fore leg of male as long as or longer than body. Tibia one and a quarter to one and one-third times as long as femur; fore tarsi approximately one and one-third times as long as tibia. First fore tarsal joint typically about one-half as long as second. In some individuals of *S. interpunctatum heterotarsale*, however, it is almost as long as second joint. Third segment subequal to second; fourth shorter than third but longer than first; fifth slightly shorter than first. Ranked in descending length, the tarsal segments of male are 2, 3, 4, 1, 5. Fore leg of female shorter than body; fore tibia subequal to femur; tarsus shorter than tibia; first tarsal joint one-half to three-quarters as long as second; third subequal to second; fifth subequal to third but longer than first, and fourth shorter than fifth. Ranked in descending length, the fore tarsal segments of female are 2, 3, 5, 1, 4. The femur of the metathoracic leg of both sexes is subequal to or slightly longer than the tibia; the tarsus about one-half of the tibia. Metathoracic fifth tarsal joint longest; in the interpunctatum and tripunctatum complexes the first joint is subequal to the second; the third is subequal to the first and the fourth is shortest. Thus the arrangement in descending lengths is 5, 2, 1, 3, 4. Species of the pulchellum complex are similar except 2 is subequal to 1 so that the arrangement is 5, 1, 2, 3, 4. Claws dissimilar on all tarsi. Typical Heptagenine venation in fore wing (figs. 1 and 3). Basal cross veins well developed. Stigmatic veins normally showing no anastomosing but may be slightly aslant. Cross veins of bullar area may or may not be crowded. Typical Heptagenine venation in hind wing (fig. 5). Between the CuA and CuP a pair of elongated marginal intercalaries. Sometimes an elongated marginal veinlet in front of the normal pair and another behind gives the appearance of two pairs of intercalaries in the cubital area of the hind wing. Male genitalia (figs. 2, 4, 6, 7 and 10) with four-jointed forceps; penes deeply divided with a strong spine on the inner side of each division. Members of the interpunctatum complex with penes shaped as in figs. 2, 4 and 6; in all others shaped somewhat as in figs. 7 and 10. Posterior margin of styliger plate straight or slightly convex in the interpunctatum complex; slightly excavated in all others. Subanal plate of female well developed, extending at least as far as tip of dorsum of abdomen; may be slightly excavated on distal margin. Median pseudocercus completely absent.

EXPLANATION OF PLATE I

1. Fore wing of *S. femoratum tripunctatum*. 2. Male genitalia of *S. interpunctatum interpunctatum*. 3. Fore wing of *S. interpunctatum interpunctatum*. 4. Male genitalia of *S. carolina*. 5. Hing wing of *S. femoratum tripunctatum*. 6. Male genitalia of *S. gildersleevei*. 7. Male genitalia of *S. pulchellum*. 8. Mandible of *S. rubromaculatum*. 9. Mandible of *S. interpunctatum interpunctatum*. 10. Male genitalia of *S. femoratum femoratum*. 11. Maxilla of *S. femoratum femoratum*. 12. Labrum of *S. interpunctatum frontale*. 13. Maxilla of *S. ithaca*.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Nymph.—Moderately flattened Heptagenine type. Head large, flattened, and wider than long with posterior margin slightly excavated. Mouthparts completely ventral; labrum (fig. 12) broad with smooth front margin; mandibles (figs. 8 and 9) slender, incisors moderately large with inner member somewhat smaller than outer; inner incisors asymmetrical, right one (fig. 17) possessing a sharp, sturdy spur which is not developed on the left member. Lacinia mobilis (fig. 18) a large, slender seta found only on left mandible and often it may be broken. Maxillae (figs. 11, 13 and 14) with two-jointed palp, the distal segment of which is sparsely setose except on outer distal surface where a denser mass of simple, long, slender setae are found. Galea-lacinia widest distally; inner lacinial edge with dense stockade of simple setae; lateral to lacinial edge is row of somewhat evenly spaced plumose setae; distal lacinial dentes slender; distal margin of galea with a variable number of heavy setae that vary from hemiplumose spines (*ithaca*) to sturdy combs (*interpunctata*). Hypopharynx (fig. 21) with wing-like super linguae. Labium (fig. 15) typically heptagenine.

Prothorax with lateral extensions that do not extend back past the anterior margin of the mesothorax. Legs flattened and tarsal claws with or without pectinations.

Gills carried dorsally and not utilized as an adhesive organ; gills one to six (figs. 20, 22, 23 and 25) double; seventh gill (figs. 16, 24 and 27) single, slender and lanceolate, lacking fibrillar portion. Tracheal branches may or may not be present in this seventh gill. Posterior lateral abdominal spines variable. Pseudocercus and two lateral cerci present.

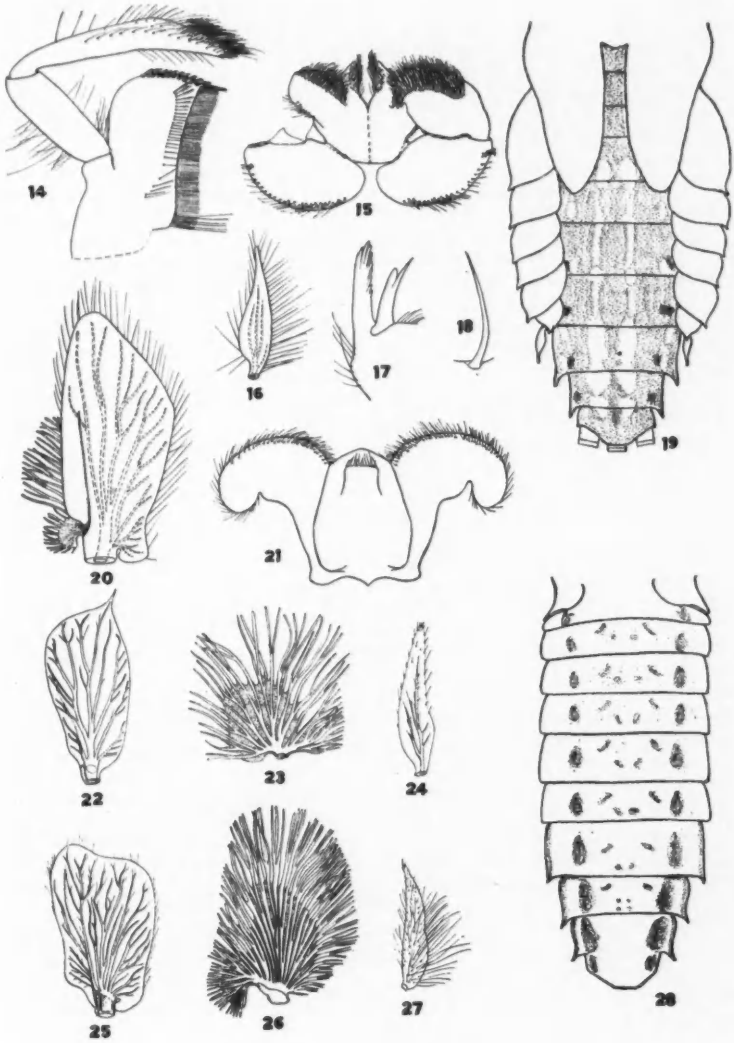
Genotype.—Stenonema tripunctatum (in *Heptagenia*) Banks.

REMARKS

This genus was erected by Traver (1933) to include certain American species that Eaton had placed in *Heptagenia*, *Ecdyonurus* and genus incerti. Some investigators had considered these species to be members of the genus *Heptagenia* (Banks, Needham, and Clemens) while McDunnough and others had placed them in *Ecdyonurus*. Ulmer (1939 and 1940) considers *Stenonema* to be a synonym of *Heptagenia*. He concludes this from the factual basis that his *Heptagenia nasuta* adults from Borneo have fore tarsal segments similar to those of *Stenonema* while the genitalia are similar to certain species that are included in *Heptagenia*. If we follow Ulmer, *Heptagenia* contains a large number of species, some of which obviously are phylogenetically quite widely diverse. The genus becomes large and unwieldy with the resultant

EXPLANATION OF PLATE II

14. Maxilla of *S. interpunctatum interpunctatum*. 15. Labium of *S. interpunctatum canadense*. 16. Seventh gill of *S. femoratum tripunctatum*. 17. Detail of right incisors of *S. fuscum*. 18. Lacinia mobilis of *S. pulchellum*. 19. Dorsal view of nymphal abdomen of *S. interpunctatum frontale*. 20. Third gill of *S. femoratum femoratum*. 21. Hypopharynx of *S. fuscum*. 22. Dorsal gill lamella of *S. interpunctatum*. 23. Ventral gill lamella of *S. interpunctatum*. 24. Seventh gill of *S. interpunctatum interpunctatum*. 25. Dorsal gill of lamella of *S. ithaca*. 26. Ventral gill lamella of *S. ithaca*. 27. Seventh gill of *S. pulchellum*. 28. Ventral view of nymphal abdomen of *S. interpunctatum frontale*.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obscuring of phylogenetic relationships. Further, if we accept Ulmer's definition of the genus *Heptagenia*, we must either (1) synonymize the genus *Ecdyonurus* as it is now delimited into the genus *Heptagenia*, or (2) divide *Stenonema* as defined by Traver between *Heptagenia* and *Ecdyonurus*. The reasons for these alternatives are as follows: The only way imagoes of *Heptagenia* (in Ulmer's sense) and *Ecdyonurus* can be separated is that in the latter the first segment of the metatarsus is longer than the second, while in the former the second metatarsal segment is longer than the first. On this basis the *pulchellum* complex would belong to *Ecdyonurus* and the *interpunctatum* and *tripunctatum* complexes to *Heptagenia*. Such a procedure would be unwarranted since we have adequate evidence from both nymphal and adult material that these three complexes are monophyletic in origin. The alternative is to fuse *Ecdyonurus*, *Stenonema*, and *Heptagenia* into a single huge genus, which would further complicate the problem of elucidating phylogenetic relationships.

The answer to the question of generic delimitation is always a difficult one for taxonomists, especially in groups such as the heptageniids where the genera appear to be closely related. The following basic factors appear pertinent to any decision that may be reached concerning *Stenonema*, *Ecdyonurus* and *Heptagenia:*

1. We assume tacitly, upon the basis of morphological evidence primarily, that all species that belong to the family Heptageniidae are of monophyletic origin. From this ancestral stock various stocks have differentiated and some of these in their turn have further differentiated, and so on.

2. Since the various species that belong to each family or to each genus have descended from a single ancestral stock, we should expect the species to have many characters that are common to all and only a few that are different. Thus the set of characters found to be possessed by any single species of the family overlaps in large part the set of characters of any other species. Conversely the characters that differentiate them from another are few in number. Further, the differences between the various species or genera within a family tend to be restricted to a given set of structures. Thus, in Heptageniidae the tarsal lengths, the penes, and certain mouthparts (but not the forceps or the abdominal gills) have apparently undergone repeated modification. To put it another way, certain characters within any given stock seem to be highly susceptible to modification and to have independently become modified many times within a stock. Other characters, and by far the greater number, remain stable and are thus similar in all individuals of the stock. Such a view has received additional support from the accumulated evidence on the mutations of such organisms as *Drosophila* where the various species have many homologous mutations.

3. We also should, to the best of our ability, be sure that all of the species included in any given genus belong to the same phylogenetic substock.

It is obvious from what has been outlined above that all categories above the species are human concepts. True, such a category as the genus should always and usually does represent a monophyletic group, but the pertinent thing is that it does not exist in nature but merely as

a concept in the human mind. An author, in establishing a genus, although he may not say it in so many words, arbitrarily chooses a locus in the phylogenetic descent of a stock and says that all species which have differentiated since this locus shall belong to the genus. His choice of a locus is naturally determined by the material at hand, namely the specimens and sundry information known about the various species. Obviously various workers may choose different loci on the phylogenetic stem. Such things as the number of species, the apparent

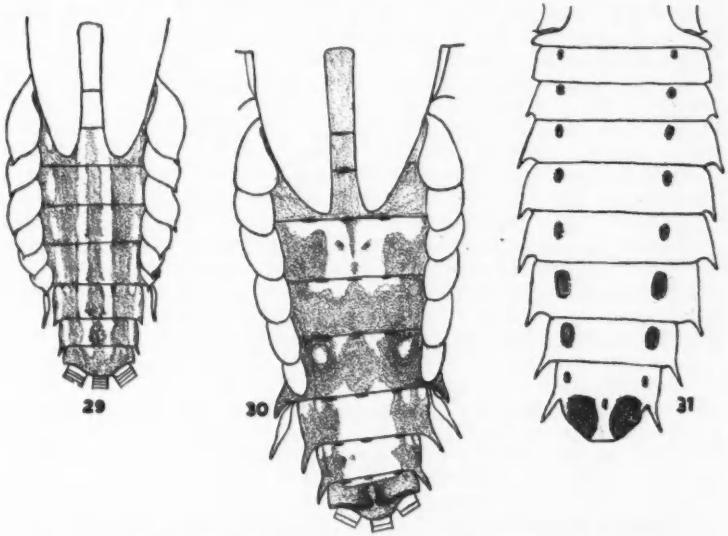


FIG. 29. Dorsal view of nymphal abdomen of *S. interpunctatum canadense.*
FIG. 30. Dorsal view of nymphal abdomen of *S. femoratum tripunctatum.*
FIG. 31. Ventral view of nymphal abdomen of *S. femoratum tripunctatum.*

homogeneity or non-homogeneity of the various species, the completeness of the information about the species, their geographical distribution, etc., will all play a part in the investigator's decision. All of these various principles have, of course, been offered time and time again by various writers and are in no sense original. I have restated them merely as a basis for the discussion of the present problem, i. e., the validity or non-validity of the genus *Stenonema.*

As defined by Traver and redefined above, the genus *Stenonema* consists of a moderate number of species that all live within a clearly delimited geographical area. All of these species have a common set of characters which they display during the various stages of their life cycles that distinguish them from other known species. The genus as defined is not unwieldy; it helps to elucidate the phylogeny within the family to which it belongs, and from all present information contains a group of species which are monophyletic in origin.

Finally, it should be noted that Ulmer (1939) added to the difficulties of the nomenclature of the wing venation by misinterpreting the cubital venation of all members of the family Heptageniidae (Ecdyonuridae of Ulmer). Needham, Traver, Hsu, etc. (1935), p. 120) state that in the hind wing "the cubital fork is extended to the wing base. Its intercalary is extended to the base also, so that the cubital triad has come to appear as three complete, subparallel, independent veins." Ulmer does not agree with this interpretation and maintains that in most heptageniids the cubital is represented by a single vein. After much study I am forced to conclude that I can not agree with either point of view. Careful comparison of the venation of the fore and hind wings shows that in generalized genera such as *Siphlonurus* and in those genera of the family Heptageniidae that I have studied (*Stenonema, Heptagenia, Iron, Ironopsis, Cinygmula, Paegnoides,* and *Thalerosphyrus*) the cubitals of the hind wing consist of *two veins*, a high or convex anterior CuA and a low or concave posterior CuP. Between these two veins detached marginal veinlets may be found as in *Stenonema*, or may be absent as in *Paegnoides*. Note that I have used the terminology advanced by Lameere (1922). This has been done because I am convinced that confusion will always exist about ephemerid venation until Lameere's views and nomenclature are utilized. As a concrete example, if either Needham and Traver or Ulmer had followed Lameere, they would not have faced the difficulties they did in interpreting the cubital veins of the hind wings of the heptageniids and other generalized forms.

BIOLOGY

The flattish nymphs of *Stenonema* are negatively phototactic and positively thigmotactic. They are normally to be found during the day time on the under sides of stones, boards, shells, etc. Although some, such as *Stenonema tripunctatum* and *S. interpunctatum*, are found in lakes, they all seem (at least during the warmer months of the year) to demand a habitat in which currents exist, due either to gravity as in streams or to winds as in lakes. So far as known, they do not live in bodies of waters which are almost, if not completely, devoid of currents, i. e., small ponds, etc. None of them, however, can ever tolerate the torrents. Thus they are normally found in regions of moderate currents.

In lakes the nymphs are found during the summer months in shallow waters and usually close to the shore. In large rivers they are congregated in areas such as rapids and falls and are almost, if not completely, lacking in the intervening quiet waters. During the colder months of the year, the nymphs (both lake and stream forms) are found in the deeper regions. In the case of the lakes that completely freeze over, the nymphs then live in an area where no currents are found.

The nymph feeds by sweeping, scraping and tearing detritus, diatoms, algae, etc., from the substratum. This is accomplished by highly efficient mouthparts.

So far as is known, no species has an egg which undergoes a diapause. The embryonic development proceeds continuously from the time the egg is deposited. Ide (1935a, p. 63) has, however, ascertained that the eggs of three females of *S. interpunctatum canadense*, all deposited at the same time and maintained under identical conditions, continued to

hatch over a period of six weeks. Further the rate of embryonic development seems dependent upon the temperature of the water, being slowed down during periods of lower temperatures. In any case the individuals overwinter as nymphs. Ide (1935b) has studied the nymphal development of *S. interpunctatum canadense, S. femoratum tripunctatum* and *S. fuscum.* He studied *canadense* most intensively and although unable to ascertain exactly how many instars it passed through (he identified thirty-five with certainty), it appears that it must shed its cuticula between forty and forty-five times during nymphal development.

The nymph, when ready to emerge, comes to the surface. Apparently some individuals may adhere to some object and partially crawl out of the water, while others emerge without any support. In the latter instances, the emerging subimago utilizes the nymphal exuvia as a raft. So far as is known, none emerges under the water as is found in the genera *Iron* (Ide, 1930) and *Ecdyonurus* (Kimmins, 1941).

After emergence, shedding of the subimaginal pellicle and the nuptial dance, all of which follow the standard ephemerid pattern, the female then deposits her eggs. These are extruded a few at a time from the oviducal openings as the female flies back and forth over the body of water into which she oviposits. Now and then she comes very close to the surface and depresses the abdomen in such a way that it touches the water and the eggs are loosened and washed off. This procedure is repeated many times.

Two types of eggs are found in the genus. The primitive interpunctatum complex has ellipsoid eggs with a coiled thread at each pole. In the tripunctatum and pulchellum complexes, the eggs are ellipsoid but lack the threads and have a gelatinous coat that swells when the egg is deposited in the water.

In the northern part of the range there is normally only one generation a year. Ide (1935a, p. 36) has shown, however, that under abnormal conditions there may be two generations each year. Further south in the range, there seems to be in some species at least two generations per year. Our information on this point is meager.

TAXONOMIC CHARACTERS

As with many ephemerids, imaginal coloration is of considerable importance in this genus. Its coloration conforms with the widespread tendency that has been set forth earlier (Spieth, 1938), namely, that those species which emerge during the spring and early summer are more darkly pigmented than are close relatives that emerge during the summer and early fall. In species of *Stenonema* which emerge over a comparatively long period of time, i. e., *tripunctatum*, the early individuals are much darker than are those that emerge later. In such species a few dark individuals, however, can be observed sometimes in the later part of the season. Whenever this occurs, it is apparently due to the fact that a smallish, spring-fed, cool stream is tributary to a larger, warm body of water. Thus the individuals that matured in the small, cold streams are exposed to the same factors as the dark forms that emerged much earlier from more normal streams in the same vicinity.

The color pattern itself is helpful but often the presence of the generalized melanistic coloration may obscure the pattern. In the wings,

pigmentation (in the form of dashes and infuscations around the cross veins) is of some aid. Color, however, is always variable no matter where or when found.

Structurally the arrangement of the cross veins, particularly the crowding or non-crowding in the region of the bulla, the length of the fore and hind tarsal segments, the ratio of the first to second fore tarsal joint, the ratio of the first tarsal joint to the fore wing length, the shape and spination of the genitalia as well as the size of the individuals, are of value. These are highly variable even to the point of varying between the two sides of the body in the case of bilateral structures, while wing length and body length show great seasonal variation. The paucity of reliable imaginal characters is one of the reasons why so much difficulty has been experienced in the taxonomy of the genus.

In the nymph, the mouthparts, especially the maxillae, the abdominal gills, the posterolateral spines of the abdominal segments, and the tarsal claws, are structural characters that are of considerable value. Again, however, we must depend primarily upon color pattern and coloration. As in the adult this must be employed with caution. Finally geographical origin and emergence time are helpful factors that can be utilized.

Stenonema tripunctatum complex

This complex consists of one species, *S. femoratum*, represented by three subspecies, i. e., *femoratum* Say, *tripunctatum* Banks, and *scitulum* Traver. All of them are restricted mainly to the Mississippi and St. Lawrence drainages although both *femoratum* and *tripunctatum* are found east and south of these two river systems. In the Mississippi drainage and the western part of the St. Lawrence system they, especially *tripunctatum* and *femoratum*, occupy the ecological and to a great extent the seasonal niche that *Stenonema vicarium* and its relatives fill in the eastern part of North America.

Taxonomically the imagoes of these subspecies are difficult to handle because practically all the structural characters and the color pattern are similar intersubspecifically, and extremely variable intrasubspecifically. If it were not for the characters of the wings, all subspecies would unquestionably be merged into one. In addition geographical ranges and emergence periods of the three broadly overlap.

On the basis of present information the complex is represented in Canada, Minnesota, Wisconsin and Michigan solely by *tripunctatum*. In Illinois, Indiana, Ohio, and New York both *femoratum* and *tripunctatum* are present and I have seen intergrades from all these states except Illinois. Both of these subspecies extend further south and also intergrade where they are found together, i. e., Georgia, Oklahoma, and North Carolina. However, in part of this area the picture is further confused by the presence of the third subspecies *scitulum*. It is separated from *femoratum* by emerging after the *femoratum* emergence period, but does intergrade with *tripunctatum*. Thus intergrades of *scitulum* and *tripunctatum* are known from Texas, Alabama, Kansas, Oklahoma, West Virginia, Illinois, Indiana and Ohio. Our knowledge is as yet quite incomplete as to the exact ranges of these three subspecies.

In general, ***femoratum*** is an early spring form that occupies the area east of the Mississippi, south of the Great Lakes, and west of the Hudson River, and extends into the southern Piedmont; ***tripunctatum*** occupies the upper and middle Mississippi and St. Lawrence drainages and follows ***femoratum*** in emergence time; ***scitulum*** is restricted to Oklahoma, Kansas, Missouri, Illinois and Indiana, emerging from early summer to late fall. *S. femoratum scitulum* and *S. femoratum femoratum* both prefer streams, perhaps exclusively, while ***tripunctatum*** prefers lakes but also lives abundantly in streams.

Perhaps the last extensive glaciation is responsible for this confused picture. Unquestionably during that period ***femoratum*** was unable to live in much of the area which it now occupies. In the unglaciated parts of southeastern North America there probably dwelt at that time, especially in the uplands, the *femoratum femoratum* stock. This stock varied from very darkly pigmented early spring emergents to much lighter *tripunctatum*-like late season individuals. Westwardly, this stock was replaced geographically by a *femoratum scitulum* stock, early emergents (seasonally) and lighter colored than the corresponding individuals of *femoratum femoratum*. With the retreat of the glacier, large areas were opened to colonization. We have considerable evidence, especially in ***Hexagenia***, that the south central and southwestern populations of ephemerids moved into this area which was exposed by the retreating glacier much faster than did the southeastern stocks. Probably it was mostly a question of drainage patterns which naturally determined the availability of routes of migration. It should be recalled that a river formed by the Wabash, lower Ohio and Mississippi formed an important, perhaps the main stream that drained the water from the glacier. When these two stocks moved back into the exposed region, the *scitulum* stock advanced most rapidly and the *femoratum* stock more slowly. From these immigrating stocks developed *tripunctatum*, but primarily *tripunctatum* seems to be derived from *scitulum*. Thus in the original territories *scitulum* and *femoratum* are still found, and both intergrade with *tripunctatum* but *tripunctatum* being primarily derived from *scitulum* shows greater similarity to that stock.

The complex is characterized as follows:

Eggs.—Ellipsoid without chorionic markings or threads, but with a gelatinous adhesive covering that swells into a thick coat upon contact with the water.

Nymph.—Sturdy, flattened stenonemids; galear portion of maxilla with two or three finely dissected setae on distal margin; second segment of maxillary palpus as in fig. 11; dorsal lamellae of gills 1–6 (fig. 20) elongate and rounded distally; 7th gill (Fig. 16) relatively sturdy, hairy and with a single trachea which may branch once; abdomen (fig. 30) with posterolateral spines on 3–9, slender 8th one longest, 9th similar in shape to 8th but shorter; spines on 3–7 stubby.

Imago.—Sturdy stenonemids which range in color from deep raw umber to pale creamy white; mesothoracic cross veins of costa, subcosta and radius always crowded in region of bulla, often margined with dark pigment; no transverse dashes of color in wings; genitalia (fig. 10) L-shaped; abdominal tergites 2–8 with three transverse dark dashes on posterior margin.

Stenonema femoratum femoratum Say

Baetis femorata Say, Western Quart. Reporter 2 (11): 162, 1823. Leconte, Complete Writ. T. Say 1: 171, 1857.
Ecdyonurus femoratus Say. McDunnough, Canad. Ent. 57: 190, 1925.
Stenonema femoratum Say. Travel, Biol. Mayflies, p. 311, 1935.

Subspecific Characteristics; Male imago.—General coloration raw umber; head and thorax raw umber with yellowish and fuscous markings; mesoscutum yellow; coxae raw umber; meso- and metafemora yellow, fore femora darker; all femora with medial and distal dark bands; all tibia with proximal darker band; longitudinal wing veins dark, immaculate and fine; mesothoracic cross veins a translucent burnt umber, robust and heavily margined with raw umber; mesothoracic cross veins at bullar region crowded in first six spaces (from costal margin to the M A), with the raw umber infuscations fusing to form a vertical streak in wing membrane; pterostigma burnt umber fading to pale raw umber distally; metathoracic wing with fine cross veins and raw umber apical cloud. Abdominal tergites 2–8 with three transverse black dashes, a median and a lateral on each side, on posterior edge; stigmal spots usually robust; tergites 2–7 yellowish brown, darker distally and laterally; 8, 9, and 10 much darker; sternites yellow, much lighter than tergites, unmarked except for faint ganglionic spots and the outer edge of 10th sternite; genitalia as in fig. 10; cerci smoky yellow, annulate with alternate segmental bands darker and broader; fore wing length 10–13 mm.

Female imago.—Similar to male except for dimorphic differences; fore wing length, 13–17 mm.

Variations in imagoes.—Specimens of *femoratum* which emerge very early in the spring display less variation than those which appear later. The general intensity of the coloration in this subspecies is relatively constant and variability is restricted mainly to the abdominal stigmal markings which vary in all degrees from large, robust ones to complete absence. Likewise the crowding of the cross veins in the bullar area, the amount of infuscation along the cross veins and finally the size of the apical cloud of the hind wing are subject to fluctuation. *S. femoratum* shows intergradation with *tripunctatum* which lives in the same area but emerges later, and thus some specimens may be placed either as dark *tripunctatum* or light *femoratum.*

Nymph.—Differs from all other known members of the *tripunctatum* complex in having the anterior margin of the head emarginate; abdominal sternites typically without the round dark spots that are characteristic of *tripunctatum*; abdominal tergal pattern as in *tripunctatum* but often much obscured even to the extent of lacking the characteristic light areas, especially the one on segments 7, 8, 9, and 10, and thus the entire dorsum appears uniform.

Variations in nymph.—The early spring emergents, i. e., the typical *femoratum*, have the dorsal abdominal pattern obscured and the ventral spots absent or present only on the posterior segments. As the season advances the mature nymphs appear more like the typical clear-cut *tripunctatum* pattern. Examples showing various degrees of intergradation between typical nymphs of *femoratum* and *tripunctatum* have been found.

Holotype.—The type material, which has subsequently been destroyed, was collected by Thomas Say at Cincinnati, Ohio, about the middle of May.

Known distribution.—Illinois, Indiana, Ohio, New York, and Georgia.

Remarks.—This robust, dark, early spring subspecies can be distinguished by the infuscation along the cross veins of the fore wing and the crowding and number of the cross veins in the bullar area from the fore margin to MA_1. This, combined with the infuscation, creates a dark band in the fore wing. The sturdy, chunky nymph is identifiable by the emarginate front edge of the head, the lack of ventral abdominal spots and the obscured dorsal pattern. The nymph appears to be a denizen of small, cool streams which probably accounts for the fact that Say found it to be scarce at Cincinnati. There exists the possibility that the differences between *femoratum* and *tripunctatum* are due to environmental rather than genetic influences. This subspecies has been associated sometimes with *pudica* Hagen. Actually there is no close relationship here; the resemblances are purely superficial. *S. pudica* is really a close relative of *Stenonema vicarium* which in turn belongs to the pulchellum complex.

Say's specimen, as McDunnough has suggested, was probably an imago. If individuals are studied in the clear daylight by means of a hand lens, the wings often, as Say indicates, appear milky. Under a binocular with strong light, this appearance disappears. In reading and checking any original description, it is always helpful to try to utilize the same magnification and lighting that the original investigator used.

Stenonema femoratum tripunctatum Banks

Heptagenia tripunctata Banks, Canad. Ent. 42: 199, 1910. Clemens, Canad. Ent. 45: 255, figs., 1913.
Ecdyonurus tripunctatus Banks. McDunnough, Canad. Ent. 65: 59, 1933.
Stenonema tripunctatum Banks. Traver, Biol. Mayflies, p. 332, 1935.
Stenonema birdi Traver, Biol. Mayflies, p. 306, 1935.

Subspecific Characteristics; Male imago.—General coloration highly variable, ranging from raw umber to creamy white; except for wings the color pattern and all structures are similar in all respects to *femoratum*, from which it varies only in the reduced intensity and tone of coloration. Mesothoracic wings with cross veins slightly, if at all, infuscated, with the bullar region having only those cross veins in the costal, subcostal and radial areas crowded and with the general intensity of coloration paler than in *femoratum*. Otherwise, wing as in *femoratum*. Metathoracic wings without apical cloud and with all veins pale or almost so; fore wing length, 10–13 mm.

Female imago.—Similar to male except for dimorphic differences; fore wing length, 13–17 mm.

Variations in imagoes.—The amount of color variation is large. The early spring forms are dark and only by drawing an arbitrary line can they be separated from *femoratum*. Late summer specimens are extremely pale, lacking all dark tints except for the pterostigmal area of the fore wing and the medial dashes on the posterior margins of the abdominal tergites. Such specimens often lack the lateral abdominal

dashes which, with the medial one, give the characteristic *tripunctatum* appearance to members of the complex. Small individuals also have relatively large compound eyes, and in the smaller males the eyes more nearly approximate each other dorsally than in the larger individuals.

Nymph.—Similar to *femoratum*; the head is not emarginate on anterior margin, but may have three small, pale spots on fore edge; abdominal tergal pattern (fig. 30) never obscured; abdominal sternites 2–8 (fig. 31) with a lateral pair of brown spots on each segment; sternite 1 lacks the brown spots and sternite 9 has two pairs, an anterior and a posterior pair. These spots increase in size progressively from segments 2–7; those on the 8th sternite are slightly smaller than on the 7th; the anterior pair on the 9th is much smaller while the posterior pair is the largest of all. A small median dash may be present between this last pair.

Type.—Milwaukee Co., Wis., 22.VII.1908, S. Graenicher collector, in Mus. Comp. Zool.

Known distribution.—Ontario and Quebec, New York, Wisconsin, Minnesota, Ohio, Michigan, Indiana, Illinois, Pennsylvania, Missouri, Oklahoma, Kansas, Texas, Alabama, Georgia, and North Carolina.

Remarks.—This is one of the most variable subspecies of the genus insofar as coloration of the imago is concerned. The nymph, however, seems rather constant. It lives in the quieter waters of streams of various sizes and seems particularly well suited to the lakes of the glaciated areas. The three dark dashes on the abdomen, the crowding of the cross veins in the first three areas of the bullar region, and the lack of the dark cloud in the apex of the hind wing will separate the subspecies from all others. *S. birdi* Traver represents a dark *tripunctatum*. It is interesting to note that *S. femoratum tripunctatum* has not been found in southeastern New York or in those states that lie east of the Hudson River.

Stenonema femoratum scitulum Traver

Stenonema scitulum Traver, Biol. Mayflies, p. 330, 1935.

Subspecific Characteristics; Male imago.—Differs from *tripunctatum* only in the small size and the presence of the brown cloud in the apex of the metathoracic wing; the compound eyes appear relatively large and nearly contiguous; length of fore wing, 8–10 mm.

Female imago.—Similar to male except for dimorphic differences; length of fore wing, 9–11 mm.

Variations in imagoes.—The color variation of this subspecies parallels that of *tripunctatum* except that no individual is as dark as the extremes of *tripunctatum*. The amount of apical infuscation varies considerably but is always present in both sexes.

Nymph.—Unknown; unquestionably close to *tripunctatum*.

Type.—Latimer Co., Oklahoma, 10.VI.31 (R. D. Bird), No. 1343.1 in Cornell Univ. Coll.

Known distribution.—Kansas, Oklahoma, Missouri, Illinois and Indiana.

Remarks.—Except for the dark tip of the hind wing, individuals in this subspecies would invariably be considered as small specimens of *tripunctatum*. In fact, individuals that have lost the hind wings cannot

be placed with certainty, although the small size is a dubious criterion. The comparatively large size of the male's compound eyes is not reliable since small individuals of *tripunctatum* also show this character. Likewise I have specimens of *tripunctatum* that occasionally display a small amount of infuscation in the apex of the hind wing.

Information now available indicates that *scitulum* nymphs are stream dwellers that emerge from June to September. Probably it commences its emergence later than does *tripunctatum* and continues later in the season, but there is a considerable period when they are both emerging at the same time.

Stenonema interpunctatum complex

This complex consists of the species *gildersleevei*, *carolina* and *interpunctatum*. *S. gildersleevei* and *carolina* occupy relatively small geographical areas, i. e., the uplands and hill country of the eastern United States. Individuals of *gildersleevei* and *carolina* are relatively uniform and, upon the basis of present information, these species display no subspeciation. *S. interpunctatum* in contrast occupies a wide area and is found in lakes and streams, both lowland and upland, and the individuals are highly variable. Numerous species have been described in the past but, employing numerous specimens as a basis, I have synonymized a number of these species and reduced the remainder to subspecific status. Due to a paucity of morphological characters, we are forced to rely mainly upon such characters as color for subspecific determinations. Genitalic as well as distinct, clear-cut color differences are available, however, for the separation of the three species. Within *interpunctatum*, degree of difference rather than absolute difference is the main delimiting criterion. No experimental evidence exists to indicate how much or how little coloration of the imaginal individuals of this genus is independent of the environment in which the nymph develops. Circumstantial evidence (Spieth, 1938) indicates, and such evidence is constantly accumulating, that the environment may play a part in determining the *degree* of coloration of the adult.

The complex is characterized as follows:

Egg.—Ellipsoid without chorionic markings but with a long terminal thread at each end which is coiled when oviposited, but which Morgan (1913) says uncoils in the water. In addition, there are several other shorter and finer chorionic threads.

Nymph.—Slender, appearing more delicate than the robust, chunky *femoratum* nymphs; galear portion of maxilla with nine or ten heavy setae that are comb-like on their distal ends; 2nd segment of maxillary palpus as in fig. 14; dorsal lamellae of gills 1–6 (fig. 22) pointed distally; tracheal distribution of these lamellae reminiscent of that found in *Heptagenia maculipennis*; 7th gill (fig. 16) sparsely setose, often with as many as three tracheal branches; no spines (figs. 19 and 29) on posterolateral corners of abdominal segments 1–6, very small spines on 7, and small slender spines, equal in length, on 8 and 9.

Imago.—Slender stenonemids that range in color from piceous brown with yellow tones to pale translucent whitish yellow, tinged with greenish; cross veins in the proximal regions of the costal and radial areas aslant, thickened and margined; in the bulla region of radial area

often a black dash connects the cross veins; genitalia (figs. 2, 4 and 6) not boot-shaped and, except for *carolina*, with a group of spines on lateral margin.

Remarks.—This complex, on the basis of the nymphal mouth parts, especially the maxillae, the nymphal gills, both shape and tracheation, the spination of the nymphal abdomen, the shape of the adult styliger plated and the penes, is more closely related to Heptagenia and Ecdyonurus than is any other part of Stenonema.

Stenonema carolina Banks

Heptagenia carolina Banks, Proc. Acad. Nat. Sci. Phila. 66: 616, 1914.
Ecdyonurus carolina Banks. McDunnough, Trans. Roy. Soc. Canada 19: 207, 222, 1925.
Stenonema carolina Banks. Traver, Jour. Elisha Mitch. Sci. Soc. 48 (2): 197, 1933. Biol. Mayflies, p. 309, 1935. Jour. Elisha Mitch. Sci. Soc. 53 (1): 38, 1937.

Specific Characteristics; Male imago.—General color gallstone yellow, faintly tinged with green; no black marking on face; eyes small and relatively widely separated; vertex tinged with orange; prothorax with slender oblique black streak on each side; meso- and metathorax unmarked; thoracic femora with medial and distal black dashes, but medial dash is lacking on the metathoracic femur; first tarsal joint of fore leg slightly less than one-half of second; radial cross veins proximal to the bulla and costal cross veins proximal to stigmal area aslant and margined with black; radial cross veins in bullar area rather heavily margined, but only rarely fused to form a dash; wing membrane of stigmal area and adjacent wing tip tinged with tawny; marginal veinlets of wing tips not thickened. Posterior margin of abdominal segments black with pigmentation heavier on tergites than on sternites; genitalia as in fig. 4; forceps pale fuscous; cerci pale fuscous with joinings very narrowly black; fore wing length, 8–12 mm.

Female imago.—Similar to male except for dimorphic differences; fore wing length, 11–14 mm.

Variations in imagoes.—Considerable size difference (8–12 mm. wing length) exists in the males of this species. The difference appears to be seasonal since the small individuals were collected late in the summer (August). Early season specimens from New York are darker than normal due to a brownish coloration on the dorsal surface, which somewhat obscures the greenish tinge. Otherwise, the individuals of the species seem remarkably constant.

Holotype.—Black Mt., N. C., May, 1913 (north fork Swannanoa Riv.). Mus. Comp. Zool.

Known distribution.—The species is found in the upland waters of eastern North America. *S. carolina* has been reported from New York, West Virginia, Tennessee, North Carolina, and South Carolina. In Canada it has been taken at Covey Hill and Knowlton, Quebec, which are located on northern outliers of the Appalachian and Green Mountains. It is absent from the lowlands of the St. Lawrence River drainage. Eventually it will probably be reported, in addition to the above areas, from the uplands of Alabama, Georgia, Virginia, Pennsylvania, Connecticut, Massachusetts, Vermont, and possibly New Hampshire.

Remarks.—Imagoes of *carolina* can be distinguished from all other species and subspecies of the interpunctatum complex by the male penes, the clear greenish-yellow coloration, and the almost total lack of black markings. The nymphs, on the basis of present information, can be identified by the lack of the continuous dorsal, longitudinal, light abdominal stripes. Since the imagoes lack stigmal spots there is no indication of these showing through the nymphal cuticle as is the case in *frontale*. Living in a relatively small area that is ecologically rather uniform, this species exhibits the least variation of any of the interpunctatum complex.

Stenonema gildersleevei Traver

Stenonema gildersleevei Traver, Biol. Mayflies, p. 315, fig. 92, 1935.

Specific Characteristics; Male imago.—General color yellow but darker dorsally, especially on abdomen; heavy black mark on clypeus under each antenna; black mark on carina at similar level, sometimes forming with lateral dashes a continuous transverse band; eyes normal for interpunctatum complex; vertex reddish-brown; prothorax with oblique black streaks; meso- and metathoracic scutella piceous; pterothoracic pleura unmarked except for a slight darkening before the mesothoracic coxae; pterosternum unmarked; all femora with medial and distal piceous areas; first tarsal joint of fore leg usually one-half of second; radial and costal cross veins proximal to bulla only slightly aslant, sometimes faintly thickened, but never margined; bullar area usually with 1–2 radial cross veins which are lightly margined but never joined to form dash; costal and subcostal membrane tinged with yellowish-green; veinlets of fore wing tip faintly thickened. Abdomen dorsally with yellow background; tergites heavily infuscated with piceous, especially along median line and posterior margins; as this infuscation fades out laterally, the combination with the yellow ground color creates a brownish color; the anteriolateral corners of the tergites lack the piceous infuscation and therefore appear yellow. Small submedian lighter areas are usually found in the deeply infuscated dorsal region. The posterior tergites are also much less infuscated than are the anterior ones. Sternites yellow with piceous infuscation along the median line, heaviest just behind the anterior margins of each sternite; ninth sternite usually tinged with red; genitalia (fig. 6) with penes longer than in *interpunctatum* and with reduced distolateral expansion; length of fore wing, 10.5–12 mm.

Female imago.—Similar to male except for dimorphic differences; length of fore wing, 12–15 mm.

Variations in imagoes.—Size variations in the species are small. The length of the male first fore tarsal joint when compared to the second is somewhat variable. Usually it is about one-half the length of the second, but in some individuals it is less than one-half and in others it is greater than half the length of the second. Thus measurements of 19 male fore legs show the ratio of the second tarsal/first tarsal to range from a minimum of 1.71 to a maximum of 2.30. Statistical analysis of this sample gives an arithmetical mean of 1.99 with a standard deviation of 0.17 and a V of 8.47. The estimated range for

this ratio is 1.48–2.50. The amount of melanistic pigmentation, especially of the abdomen, varies considerably. The abdominal tergites of some specimens are intensely and broadly blackened. These individuals have a complete frontoclypeal band, have the abdominal sternites considerably darkened and show no signs of abdominal stigmal spots due to the covering effect of the dorsal coloration. In others the black pigment of the abdominal tergites is much reduced and mainly concentrated near the medial line. In such specimens the clypeus has a dash under each antennae and a blackish mark on the carina, while the abdominal sternites may almost lack any dark colors and stigmal spots are visible, especially on segments 2–6.

Nymph.—Head without anterior light marginal area; abdomen with a narrow transverse piceous stripe on terminal edge of each tergite; medial part of tergites, especially the anterior ones, infuscated; a pair of submedial, light areas on each tergite, these tending to be oval and not linear, small on the anterior segments but longer posteriorly. These light areas give the abdomen the lined appearance typical of the interpunctatum complex, which is less evident than in *canadense* but more evident than in *carolina*. Sternites immaculate except for dark lateral dashes on segments 7–10.

Holotype.—Kirtland, O., August 31, 1930 (spring-fed stream of Gildersleeve Mt.), No. 1337.1 in Cornell Univ. Coll.

Known distribution.—The species has been collected in northern and southern New York and northeastern Ohio. The intensive collecting done by numerous Canadian entomologists has failed to discover any specimens of *gildersleevei* in Canada. It probably occupies a limited area in the northern Appalachians.

Remarks.—Imagoes of *gildersleevei* can be readily distinguished by the male genitalia, the concentration of black pigments on the mediodorsal part of the abdomen, and the unmargined, almost vertical radial and costal cross veins. The yellowish ground color is also distinctive. Unquestionably it has been confused in the past with *canadense*. *S. canadense*, however, has the piceous pigments much more widely distributed, especially on the thorax, and the margined, slanting cross veins plus the usually present bullar dash are distinctive characters for its separation from *gildersleevei*.

The type of *gildersleevei* was reared from the mature nymph which was found in a cold spring-fed stream. This holotype, plus the allotype and 8 paratypes all from the same locality, emerged in late August and early September. Traver also reared specimens at the same time from a nearby locality which she described as *ohioense*. She indicates (1935, pp. 316 and 322) that *ohioense* is rather closely related to *gildersleevei*. Study of the type of *ohioense* shows it to be a synonym of *canadense* and not closely related to *gildersleevei*.

Stenonema interpunctatum Say

This species consists of four subspecies, *interpunctatum* Say, *canadense* Walker, *frontale* Banks, and *heterotarsale* McD. *Stenonema candidum* Trav., *conjunctum* Trav., *major* Trav., *pallidum* Trav., and *proximum* Trav. have been described as species of the interpunctatum complex, but are synonyms of the four subspecies listed above. Traver

(Biol. of Mayfies, p. 316) synonymized *Stenonema affine* Traver with *heterotarsale* McD. Study of numerous individuals from a large number of localities, including all the types except that of *interpunctatum* s. str. which is nonexistent, has made it possible to modify the taxonomy of this complex.

Geographically *interpunctatum* is the most widespread species of Stenonema and apparently is found throughout the entire range of the genus. The nymph lives in streams, or in bodies of water where stream conditions are simulated, but it can not tolerate swift currents. It seems to be more hardy and adaptable than are most species of the genus.

The emerging imagoes become smaller in size and lighter in color as the season progresses, thus paralleling the condition found in *S. tripunctatum*. This phenomenon of size and pigment reduction as the season progresses is apparent only in areas which are ecologically uniform and in which only one subspecies is present. In areas where subspecies overlap and intergrade, the resultant mixed population may appear not to follow this pattern, especially so far as color is concerned. The picture is further complicated in such areas by seasonal and ecological isolation. Thus Ide (1935, p. 46) found that *heterotarsale* and *canadense*, both of which live in the Mad River, Ontario, overlap only slightly in their ecological and seasonal occurrence; *canadense* emerges earlier in the season and lives further up-stream, i. e., in colder water. Only at the upper range of *heterotarsale* and the lower limit of *canadense* do they overlap both in space and time. In regions where a large warm stream has numerous small spring-fed tributaries, it is to be expected that series can be collected which will show both subspecies to be plentiful at the same time, i. e., late emergents of the early form from the cool tributaries and early emergents of the late form from the warm stream.

Adequate sampling from such an area will always bring to light numerous intergrades. Sometimes the collection is complex, e. g., a series that I collected July 1 from the Lachine Rapids on the St. Lawrence River contains typical specimens of *canadense*, *frontale*, and *heterotarsale* and all intergrades between them; one specimen, except for the long first tarsal joint, can not be told from typical specimens of *interpunctatum* from southern Indiana.

The characters employed to separate these subspecies of *interpunctatum* deserve a word of comment. In the past, genitalic differences have been used but careful study of a series of genitalic preparations convince me that within the species any differences are either individual or caused by the technique used in the preparation of the specimen. Likewise, the length of the first tarsal segment has been used and is of considerable value but is highly variable. The ratio derived by dividing the length of the second segment of the male fore tarsus by the length of the first segment provides a character that can be handled statistically to good advantage. Likewise the ratio derived from the fore wing length divided by the first segment of the male fore tarsus is useful. Due to the paucity of such charaters, coloration has been commonly utilized, especially the following: (1) the amount of black pigmentation on (a) the clypeus, (b) the prothorax, (c) the pterothoracic pleura, (d) the abdomen, especially the dorsum, and (f) the

cercal joinings; (2) the presence or absence of stigmal spots on the abdominal tergites, and (3) the bullar streak of the fore wings. All of these characters exhibit great variability—seasonally as well as individually. Size parallels coloration in variability. On the basis of present information, it can be said that in any given locality the early seasonal emergents are larger and darker than those that emerge later. Size and coloration thus display both seasonal and individual variation, and the latter type is of considerable magnitude.

Those species listed above which have been synonymized all appear to be color variants of the four subspecies that have been retained. The four subspecies, comprising the species, are distributed as follows: *interpunctatum s. str.* is found mainly in the lower and middle Mississippi and the Ohio River drainages; *canadense* in eastern Canada, in the northern tier of eastern and mid-western states, and extending southward along the eastern highlands; *frontale* in the eastern part of the United States, extending westward along the shores of the eastern Great Lakes. Finally, *heterotarsale* is centered around Lake Erie and Lake Ontario and extends westward into northern Indiana and Illinois.

Stenonema interpunctatum interpunctatum Say

Baetis interpunctata Say, Jour. Acad. Nat. Sci. Phila. 8: 41, 1839. Complete Writings of Thomas Say, 2: 411.
[nec] *Heptagenia interpunctata* Say. Eaton, Mono. Rec. Ephem., pt. 4: 267, 1885. Clemens, Canad. Ent., 56: 17, 1924.
Ecdyonurus interpunctatus Say. McDunnough, Canad. Ent., 65: 42–43, 1933.
Stenonema interpunctatum Say. Traver, Biol. Mayflies, pp. 317–318, 1935.
Stenonema affine Traver, J. Elisha Mitchell Sci. Soc. 48: 184, 1933.
Stenonema pallidum Traver, Biol. Mayflies, pp. 323–324, 1935.

Subspecific Characteristics; Male imago.—General color chrome yellow, faintly tinged with green; black dot on clypeus under each antenna; eyes normal in size; vertex reddish-brown; prothorax with oblique black streak on each side; pterothorax unmarked except for mesonotum which is normally pale chestnut; metathoracic femur with distal dark band but normally lacking medial; second tarsal/first tarsal ratio from 1.8 to 3.5 with about 2.6 as the most common; radial cross veins proximal to the bulla and costal cross veins proximal to the stigmal area aslant and margined; a black dash in radial area at level of bulla, often connecting two or more cross veins; wing membrane of costal and subcostal areas yellowish, with stigmal area and wing tip slightly darker; marginal veinlets of fore wing tip thickened; wing length varying from 5.8 to 10.1 mm. with about 8 mm. as the most common; abdominal tergites 1–8 pale translucent yellow; distal part of 8 and all of 9 and 10 ferruginous; all tergites with narrow piceous posterior margin; sternites unmarked; genitalia (fig. 2) cream colored; cerci pale with joinings faintly darkened.

Female imago.—Similar to male except for dimorphic differences.

Variations in imagoes.—The description given above is from a typical specimen collected at New Harmony, Indiana. Individuals that emerge in the early spring tend to be large and somewhat darkened due to the dorsum of the abdomen being infuscated with blackish while the metathoracic leg may have a dark medial band. Some individuals, irrespective of emergence time, show faint stigmal spots such as are

normally found in frontale. Measurement of 20 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 2.15 to 3.5 with a mean of 2.63, a standard deviation of 0.28 and a coefficient of variation (v) of 10.65. The standard error of the mean is ±.063. The distribution of the sample is positively skewed. The estimated range is 1.79 to 3.47. The forewing of 20 specimens gave an observed range of 6.6–9.05 mm. with a mean of 7.98 mm., a standard deviation of 0.72 and a coefficient of variation of 9.02; the standard error of the mean is ±.16. The estimated range of the wing is 5.82–10.14 mm. The wing length, unlike the tarsal ratio, is influenced by seasonal variation.

Known distribution.—Mississippi River drainage, especially the middle and lower parts, and the Ohio River drainage.

Remarks.—The subspecies can be identified by the general yellow coloration, the lack of dark markings on the pterothoracic pleura, and the typically short first segment of the fore tarsus. As mentioned above, Say's description fits material that is possibly topotypical. Large specimens of ***heterotarsale*** may be confused easily with this subspecies and we may expect to find specimens of ***heterotarsale*** with fore wings that equal or exceed the longest wings of ***interpunctatum***. The male second/first tarsal ratio and the dependent wing/tarsal ratio seem to be good criteria and the only fairly dependable ones available for separating some individuals of ***heterotarsale*** from ***interpunctatum***. It is possible that specimens from the southeastern United States which have been considered as belonging to ***interpunctatum*** may belong to ***frontale***. This also applies to Traver's ***pallidum***. The reasons for such possible deductions are discussed below in the full discussion. In any instance, more specimens from such areas will be needed before a final decision can be drawn.

Stenonema interpunctatum canadense Wlk.

Baetis canadensis Walker, List Neuropt. Ins. Brit. Mus., pt. 3: 569, 1853.
Ecdyurus canadensis Walker. Eaton, Revisional Mono. Rec. Ephemeridae, part 4: 278, 1885.
Heptagenia canadensis Walker. Clemens, Canad. Ent. 45: 258, 1913.
Ecdyonurus canadensis Walker. McDunnough, Trans. Royal Soc. Canad., 19 (sec. 5): 222, 1925.
Stenonema canadense Walker. Traver, Biol. Mayflies, p. 307, 1935. Ide, Canad. Jour. Res., 12: 447–457, figs., 1935. Spieth, Ann. Ent. Soc. Amer., 33: 333, 1940.
Stenonema ohioense Traver, Biol. of Mayflies, p. 322, 1935.

Subspecific Characteristics; Male imago.—General coloration typically yellowish with enormous amount of piceous color, especially dorsally; superficially much like *S. gildersleevei* Trav. Differs from ***interpunctatum*** mainly in the increased amount of black infuscation. Clypeus with horizontal piceous band; eyes normal; vertex as in ***interpunctatum***; prothorax with oblique bands and lateral markings; pterothorax with oblique, piceous pleural streaks from each wing base; mesonotum darker than in ***interpunctatum*** and with scutellum piceous; metascutellum dark; metathoracic femur with both distal and medial bands; first tarsal joint about as in ***interpunctatum***; the second tarsal/first tarsal ratio varying from 1.6 to 3.1 with 2.3 as the most common; wings marked as in ***interpunctatum*** but more intensely; bullar area usually ferruginous.

Dorsum of abdomen broadly piceous with scimitar-shaped, paired, subdorsal pale streaks; areas that are not infuscated with piceous translucent to transparent and not colored with yellow as in *gildersleevei*; wing length varying from 6.6 to 12.1 mm. with about 9.3 mm. as the most common; sternites hyaline or semihyaline but often tinged with black; genitalia as in *interpunctatum*; cerci pale with dark joinings.

Female imago.—Similar to male except for dimorphic differences.

Variations in imagoes.—A large amount of variation exists in the amount of black infuscation which characterizes the subspecies. This can be attributed to three causes, but which is responsible in any particular individual it is impossible to say. These causes are: (1) individual variation; (2) seasonal variation, late seasonal emergents usually being much lighter in color; (3) interbreeding with lighter colored subspecies. The lightly infuscated individuals invariably display robust stigmal spots on the abdominal tergites. Apparently these are obfuscated in the darker individuals by the dark coloration of the tergites.

Measurement of 43 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 2.00 to 3.00 with a mean of 2.34, a standard deviation of 0.257 and a V of 11.0. The standard error of the mean is ±.039. The distribution of the sample is positively skewed. The estimated range is 1.57 to 3.10. The fore wing length of 26 male individuals ranges from 8.28 to 9.95 mm. with a mean of 8.96, a standard deviation of 0.389 and a V of 4.34. The standard error of the mean is ±.076 and the estimated range is from 7.8–10.13 mm. Sometimes individuals are found that agree with *canadense* except for long first tarsal joints. These apparently are intergrades with *heterotarsale*.

Nymph.—Head without anterior light marginal area; abdomen (fig. 29) darker than thorax; four longitudinal abdominal streaks, two submedianly and the others near lateral margin; future stigmal dots of imago often visible; abdominal sternite with two light brown lateral streaks on white background; ninth sternite with lateral and posterior margins infused with same color.

Holotype.—Canada, in Walker Coll. in Brit. Mus. (Nat. Hist.). Nymph associated with imago by Clemens, 1913, at Go-Home-Bay, Georgian Bay, Ontario, Canada.

Known distribution.—Quebec, Ontario, Minnesota, Michigan, Illinois, Indiana, Ohio, New York, Connecticut, New Jersey, West Virginia, Tennessee, and North Carolina.

Remarks.—Clemens (1924) first indicated that this is a subspecies of *interpunctatum*. Superficially it is nearer to *S. gildersleevei* than is any other species of the complex. The genitalia, the color pattern, and the fore wing pattern are reliable means of separating the two. Typical specimens can not be confused with any of the other subspecies of *interpunctatum*. Lightly infuscated individuals, regardless of the cause, are extremely difficult to separate from *frontale*, or, if they also lack the stigmal spots, from *interpunctatum* and *heterotarsale*. Clemens (1913) reared and adequately described the nymph. It is typical of the interpunctatum complex. Upon the basis of my present information, I can not separate it from nymphs which I think belong to *interpunctatum*.

Stenonema interpunctatum frontale Banks

Heptagenia frontalis Banks, Canad. Ent., 42: 199, 1910. Clemens, Canad. Ent., 45: 259, fig. nymph, 1913.
Ecdyonurus frontalis Banks. McDunnough, Canad. Ent., 62: 61, 1930. Canad. Ent., 65: 43, 1933.
Stenonema frontale Banks. Traver, Biol. Mayflies, p. 312, fig., 1935.
Stenonema candidum Traver, Biol. Mayflies, p. 308, 1935.
Stenonema conjunctum Traver, Biol. Mayflies, pp. 309–310, 1935.
Stenonema majus Traver, Biol. Mayflies, p. 320, 1935.
Stenonema proximum Traver, Biol. Mayflies, p. 325, 1935.

Subspecific Characteristics; Male imago.—General color chrome yellow, faintly tinged with green; black dash on clypeus under each antennae and a spot on carina at the same level; eyes normal; vertex as in *interpunctatum*; prothorax with oblique band and black dot on posterolateral corner; pterothorax with oblique piceous pleural streaks from each wing base; mesonotum darker than in *interpunctatum* but lighter than in *canadense*; meso- and metascutella yellow; metathoracic femur with medial and distal bands; second tarsal/first tarsal ratio more variable than in *interpunctatum* or *canadense*, ranging from 1.2 to 3.5 with approximately 2.3 as the most common; wings as in *interpunctatum* except bullar dash is often restricted and does not join several cross veins; the wing length varies from 6.6–12.1 mm. with about 9.38 mm. as the most common. Abdomen as in *interpunctatum* except for heavier posterior black margins and the presence of prominent robust stigmal spots; genitalia as in *interpunctatum*; cercal joining darker than in *interpunctatum*.

Female imago.—Similar to male except for dimorphic differences.

Variations in imagoes.—Normal variation appears to be large and, especially where *frontale* intergrades with populations of *canadense* and *heterotarsale*, an extremely variable population is formed. Measurement of 56 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 1.6–3.2, with a mean of 2.37, a standard deviation of 0.39 and a V of 16.60. The standard error of the mean is ±.052. The distribution of the sample approaches that of normal but indicates considerable variability for this character of the subspecies. The estimated range is from 1.19–3.55. The fore wing of 42 males varies from 6.77–11.2 mm., with a mean of 9.38 mm. and a standard deviation of 0.92 and a V of 9.7. The standard error of the mean is ±.16 and the estimated range is from 6.62–12.14 mm.

Nymph.—Often with a pale spot on anteromedial margin of head; dorsal abdominal color pattern (fig. 19) distinctive due to the reduction of the longitudinal light streaks that are present on the nymphal abdomens of the other subspecies. Sternites as in fig. 28.

Holotype.—Middlesex Falls, Mass., August. In Mus. Comp. Zool. Coll.

Known distribution.—Nova Scotia, Quebec, Ontario, New Hampshire, Vermont, Massachusetts, New York, and Ohio.

Remarks.—Typical specimens, either as nymphs or imagoes, of this subspecies are easily identified, the nymphs by the distinctive dorsal abdominal pattern and the adults by a combination of stigmal spots, thoracic coloration, and wing pattern. All degrees of intergradation exist between *frontale* and *canadense*, *frontale* and *heterotarsale*, and

frontale and *interpunctatum* in both the nymphal and the imaginal stages. The abdominal pattern of the nymph figured by Traver (1935, Pl. 24) is not typical for *frontale* and probably indicates *canadense* hybridization. The genitalic differences between *canadense* and *frontale* as given by Traver (1935, fig. 91) apparently are individual rather than specific or subspecific. *S. candidum* Trav., *conjunctum* Trav., *majus* Trav., and *proximum* Trav. are not quite typical examples of *frontale*. Actually, study of the types indicates that they represent intergrades (or environmental variants) of *frontale* with other subspecies. Since they are more nearly like *frontale*, I have synonymized them with it. *S. candidum* deserves mention in that the differences, given by Traver (1935), are restricted to the genitalia. According to the original description (Traver, 1935, p. 308) only three individuals of *candidum*, two males and one female, were known. At Cornell I found the male holotype from which the genitalia had been detached. Except for the penes it agreed in all respects with *frontale*. The mounted genitalia which merely bore the same data as the type, but no number or other identifying mark that would connect it with the holotype, agree with Traver's figure and certainly resemble those of *S. carolina*. Unfortunately the male paratype, except for a mounted wing and the nymphal skin, has been lost. These remaining parts bear facies of *S. frontale*. Perhaps one of two things has occurred: (1) either the genitalia attributed to the holotype are those of a specimen of *carolina*, or (2) the holotype was an aberration lacking the lateral genitalic spines. In any instance, I consider it to be a synonym of *frontale*.

Stenonema interpunctatum heterotarsale McD.

Ecdyonurus heterotarsale McDunnough, Canad. Ent., 65: 42, 1933.
Stenonema heterotarsale McDunnough. Traver, Biol. Mayflies, p. 316, 1935.

Subspecific Characteristics; Male imago.—General coloration as in *interpunctatum*. Differs from *interpunctatum* in the lack of black markings and the greater length of the first fore tarsal joint. Clypeus unmarked; head otherwise as in *interpunctatum*; prothorax unmarked; pterothorax without black marks; mesonotum, metanotum, wings, and markings on legs as in *interpunctatum*. First segment of fore tarsus long; the second tarsal/first tarsal ratio ranging from 1.0–2.1 with 1.6 as the most common. Wing length varies from 5.0–10.2 mm. with about 7.5 mm. as the most common. Abdomen, including genitalia and cerci, as in *interpunctatum*.

Female imago.—Similar to male except for usual dimorphic differences.

Variations in imagoes.—Typical specimens as described are not very numerous. Only the size and long first tarsal joint seem relatively constant. Many individuals, although much lighter than those of *interpunctatum*, do have some dark markings. This is especially true of the clypeal marks, the oblique prothoracic marks, and stigmal marks. Measurement of 44 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 1.15–1.95 with a mean of 1.57, a standard deviation of 0.18 and a V of 11.4. The standard error of the mean is $\pm$.026. The distribution of the sample approaches normal. The estimated range for this ratio is 1.03–2.10. The fore wing length of 22

individuals ranges from 6.18–9.22 mm. with a standard deviation of 0.87, a V of 11.57, and a mean of 7.59. The standard error of the mean is ±.187 and the estimated range is 4.95–10.23 mm. Thus, both wing length and tarsal ratios may be expected broadly to overlap those of the other subspecies. Note that seasonal emergence plays a large role in wing length.

Nymph.—Undescribed, but probably close to *interpunctatum.*

Holotype.—Ottawa Golf Club, Quebec, 2.VII.24, No. 3527 Canadian Nat. Coll., Ottawa.

Known distribution.—Northern Ohio, northern Indiana, northern Illinois, Michigan, northwestern New York, Ontario, southwestern Quebec. This subspecies seems to be centered around Lake Erie and Lake Ontario.

Remarks.—S. affine Traver (1933) is probably a synonym of *interpunctatum s. str.* rather than of *heterotarsale* as she suggested (Traver, 1935). *S. heterotarsale* emerges on the average later in the summer than does any of the other subspecies of *interpunctatum.* It is possible that those specimens that have been placed in *heterotarsale* are merely late season individuals of *frontale.* Certainly size and fore tarsal segmental length are highly variable, and the casual student of ephemerids will find *heterotarsale* a rather exasperating subspecies to delimit.

DISCUSSION AND STATISTICS OF THE STENONEMA INTERPUNCTATUM COMPLEX

Study of all existing types and various collections (i. e., Cornell University, Museum of Comparative Zoology, Canadian National Collection, University of Michigan, Illinois Natural History Survey, American Museum of Natural History, plus my own collection) show the presently accepted species picture of the interpunctatum complex to be questionable. *Stenonema carolina* Banks and *S. gildersleevei* Traver are distinct species that can be definitely delimited and identified. The remaining nine species of the complex present a complicated and irritating problem. Comparison of numerous individuals with the holotypes shows that some specimens correspond closely with the types, but many individuals are clearly intermediate. Study of the available paratypes shows that many of them vary considerably from the holotypes. When confronted with a large series, especially from the areas around the Great Lakes, more "intermediate" than "typical" specimens are invariably found. All evidence indicates that some of the existing names need to be synonymized and the remainder reduced to subspecific status.

Such a revision seems rather drastic and I wished to study all available evidence before reaching a final decision. The following procedure was therefore undertaken. Utilizing my own collections and those of the American Museum of Natural History, all specimens of the complex, other than those of *S. carolina* and *S. gildersleevei*, were sorted according to geographical distribution and date of collection. Utilizing pinned adult males, those specimens that were relatively perfect were given individual numbers and then the following data were recorded in tabular form for each specimen: (a) length of first and second tarsal seg-

ments of fore leg, (b) coloration of thorax, (c) coloration of abdomen, (d) presence or absence of abdominal stigmal markings, (e) length of fore and hind wings, and (f) number of x-veins involved in the bullar dash or spot of the fore wing. For the coloration records, four arbitrary grades of ascending order of intensity, 0, 1, 2, and 3, were established. A low power binocular microscope was used for magnification. Tarsal segment measurements were made with 1.7x oculars and 2.3x objectives. Wing length measurements and all other data were recorded with 12.5x oculars and 1.0x objectives. An artificial light source (microscope lamp with "daylight" glass filter) was used to illuminate the specimens. Specimens preserved in alcohol were not used, although many were available, because the colors, especially those other than the melanins, fade rather rapidly and also because the male fore legs so often become detached. The information from series of individuals collected at the same place and time was then tabulated. Within the limits of availability, series were studied from the entire geographical range of the complex. Later, after these data had been studied, individual specimens or small series from what appeared to be critical areas were also studied and measured. In all, two hundred and one (201) specimens were so treated. Twelve (12) of these specimens were individuals of *S. gildersleevei* which were measured and utilized for comparative statistics.

The data thus assembled were subjected to statistical analysis. Not all of the characters could be subjected to the simple statistics employed, but they could be used in connection with those characters that were so analyzed. The arithmetic mean (M), the standard deviation (σ) and the coefficient of variation (V) were determined for the second/first tarsal segment ratio, the fore wing length, and the wing length/first tarsal segment ratio.[1, 2] The two ratios gave pure numbers that are independent of the absolute size of the individuals. This is important because stenonemids vary in size not only individually but also seasonally. In utilizing the data the assumption has been made that size, variation, both individual and seasonal, exert no effect on the ratios derived from the tarsal and wing measurements.

Since the coefficient of variation is a measure of relative variability, more weight has been given to it than to the absolute measurements. This will become more evident in the specific discussions below.

Note also that unless special mention is given whenever a series is considered, all the specimens taken at that particular place at that time have been utilized. Some individuals, however, lack legs (due to breakage subsequent to collection) while others possess wings that are unmeasurable, and therefore the total for the two series may vary for the different measurements.

Having determined the M and σ of each sample, an estimate was then made of the parameter of the particular population from which the

[1]Since the cross hatched measuring scale was placed below the lens system of the ocular, by multiplying the wing length by 2.3 the resultant figure was of the same size units as those of the tarsal segments.

[2]The computations were accomplished with the aid of FORM FOR MEAN and STANDARD DEVIATION by Tryon and Searle, 1941, based on 1935 Form by R. C. and C. McC. Tryon.

sample was drawn. This was done by adding or subtracting three standard deviations from the mean (Tables I, II, and III). Finally, after the data had been analyzed and conclusions reached, a series of individuals typical for each of the four subspecies retained was selected and the statistics assembled. These series were treated similarly to the geographical series and will give at least the author's conception of the various subspecies which he considers valid.

A series of specimens collected 26.VI.38 from Alymer, Quebec, omitting one specimen of ***heterotarsale***, agree in all respects with the accepted definition of ***canadense***. The ratio derived by dividing the length of the second tarsal segment of the ♂ fore leg by the first tarsal segment of the same leg (hereafter called, for convenience, the second tarsal/first tarsal ratio) gives for this series (Table I) a maximum of 3.00, a minimum of 2.00, a M of 2.35 and a V of 11.72. A small series combined from specimens collected at Louisville, Ky., and New Harmony, Ind., displays (Table I) a maximum of 2.71, minimum of 2.29, M of 2.52, and a V of 5.81. These specimens are all typical ***interpunctatum***. From Lexington, N. Y., 11.VI.38, all individuals which agree with the delimitation of ***frontale*** show (Table I) a maximum of 2.71, a minimum of 1.82, a M of 2.29 and a V of 10.25. In comparison, a series collected at the Lachine Rapids, Montreal, Que., 1.VII.38, shows individuals ranging in color from very pale yellow to examples almost as dark as the darkest ***canadense***. The tarsal ratio for the series varies from 2.83 to 1.14, with a M of 1.79 and a V of 20.90. Clearly this sample is more variable than the preceding three. If these specimens are sorted on the basis of thoracic coloration and those with grade 0 and 1 are separated from the darker grade 2 (there are no grade 3 specimens), then (Table I) the variability especially of the grades 0 and 1 specimens drops sharply to a V of 8.64 but that of the grade 2 specimens actually increases (21.80). Removal of one individual (No. 21) which has a dark thorax but a long first tarsal segment is sufficient to drop the V of the grade 2 specimens to 17.75. Sorting the specimens on the basis of the abdominal coloration gives a similar but reversed picture. The grade 2 individuals possess a V of 14.0 while the grades 0 and 1 have a V of 20.8. Removal of one specimen (No. 3) which has a light colored abdomen and a short first tarsal segment reduces this V from 20.8 to 11.7. Thus, two distinct populations seem involved in the series. Removal of the two intergrades leaves a light colored, long first tarsal joint group with a V equal to those of the "pure" series and a dark colored, short first tarsal joint group of slightly greater variability. The long first tarsal joint, light colored specimens represent ***heterotarsale***, while the short first, tarsal joint, dark colored specimens are ***canadense***. Ide (1935) found that both ***heterotarsale*** and ***canadense*** live in the same Ontario stream (Mad River) but the latter at higher elevations and the two populations only slightly overlap in space and emergence time at this particular locality. Evidence from localities other than the Lachine Rapids contributes additional information that ***heterotarsale*** intergrades not only with ***canadense*** but also with ***interpunctatum***. Thus, from Orillia, Ont., 7.VII.38, a series of thirteen (13) individuals vary from light (Grade 0) to dark (Grade 2) and one of the intermediate specimens (thorax, Grade 1; abdomen, Grade 2) has a

TABLE I

RATIO OF $\frac{\text{2ND TARSAL SEGMENT}}{\text{1ST TARSAL SEGMENT}}$ OF ♂ FORE LEG

PART I. Arrangement by Locality

Locality and Date	Total Spec.	Observed Range		M	σ	V	Estimated Range		Notes
		Max.	Min.				Max.	Min.	
Lachine Rapids, Que., 1-VII-38	39	2.83	1.14	1.79	.376	20.90	2.92	0.66	All specimens
Same	21	2.00	1.43	1.64	.140	8.64	2.06	1.22	Spec. with Thorax 0 and 1
Same	18	2.83	1.14	1.95	.421	21.80	3.19	0.67	Spec. with Thorax 2
Same	16	2.83	1.60	1.98	.352	17.75	3.03	0.93	Spec. with Thorax 2; spec. 21 omitted
Same	29	2.83	1.14	1.65	.360	20.80	2.73	0.57	Spec. with Abdomen 0 and 1
Same	27	2.00	1.14	1.57	.185	11.70	2.12	1.02	Spec. with Abdomen 0 and 1; spec. 3 omitted
Same	10	2.57	1.75	2.01	.280	14.00	2.85	1.27	Spec. with Abdomen 2
Aylmer, Que., 26-VI-38	36	3.00	2.00	2.35	.278	11.72	3.18	1.52	All spec. have Abd. and Th. 2 or 3
Louisville, Ky., 22-VIII-40; New Harmony, Ind., 16-VI-36 and 30-V-40	14	2.71	2.29	2.52	.147	5.81	2.97	2.09	
Massey, Ont., 23-VI-36	10	1.87	1.50	1.66	.114	6.85	2.00	1.32	Th. and Abd. 0, but stigmal spots present
Sloatsburg, N. Y., 4-VI-33	20	3.25	1.67	2.53	.430	17.00	3.82	1.24	Th. and Abd. mostly 2; all with stigmal spots
Same	18	3.25	1.90	2.63	.332	12.60	3.62	1.63	Spec. 81 omitted; 81 has Th. and Abd. 0
Lexington, N. Y., 11-VI-38	20	2.71	1.82	2.29	.235	10.25	3.00	1.59	All spec. with stigmal spots
Bluffton, Ind., 20-VII-29	20	2.76	1.13	1.56	.416	26.70	2.80	0.32	
Same	15	1.66	1.13	1.35	.131	9.70	1.74	0.96	Spec. 136, 137, 151 omitted

PART II. Arrangement by Taxonomic Category

Category	Total Spec.	Observed Range		M	σ	V	Estimated Range		
		Max.	Min.				Max.	Min.	
canadense	43	3.00	2.00	2.340	.257	11.00	3.11	1.57	
frontale	56	3.20	1.60	2.370	.394	16.60	3.55	1.19	
interpunctatum	20	3.50	2.20	2.630	.280	10.65	3.47	1.79	
heterotarsale	44	1.90	1.10	1.57	.178	11.30	2.10	1.03	
gildersleevei	19	2.30	1.70	1.992	.169	8.50	2.50	1.48	

tarsal ratio of 1.67. One light specimen had a tarsal ratio of 2.00 for one leg and 1.80 for the other leg, and is typically ***interpunctatum*** in facies. Most of this series were dark (***canadense***) in appearance. As the season progresses ***heterotarsale*** becomes more numerous vis a vis ***canadense*** and ***interpunctatum***. A series of eight specimens from Elkhart, Ind. (St. Joseph's River), 3.V.40, shows two individuals to have long first tarsal joints as well as typical ***heterotarsale*** coloration. The other six are definitely of the ***interpunctatum-canadense*** type (they could be either dark ***interpunctatum*** or light ***canadense***) and have short first tarsal joints. A collection of six individuals from the same locality and the same area of the St. Joseph's River, but made 14.VIII.40, consists of one ***interpunctatum*** and five typical ***heterotarsale***. A collection of eleven specimens from Montreal, Que., 5.IX.34, consists mostly of ***heterotarsale*** type individuals, but two specimens are decidedly of the ***canadense*** type and one of these has a ***canadense*** ratio (2.00) and the other a ***heterotarsale*** ratio (1.33 and 1.38). Finally, the most mixed series available is from Bluffton, Ind., 20.VII.29. Eighteen specimens vary in coloration from typical ***heterotarsale*** and ***interpunctatum*** to light ***canadense***. The tarsal ratio of these (Table I) gives a V of 26.7 with a mean of 1.56. However, if specimens No. 136 and No. 139 (both light ***canadense***) and No. 151 (typical ***interpunctatum***) are omitted, then the remaining individuals have a tarsal ratio M of 1.35 with a V of 9.70. These individuals have ***heterotarsale*** tarsal ratios and are mostly pale colored, but several of them are atypical in having black marks on the thorax and all possess stigmal spots on the abdomen. As noted under the description of ***heterotarsale***, many individuals do have piceous markings and the commonest seems to be the presence of pterothoracic streaks and abdominal stigmal spots. All specimens of a small collection of ***heterotarsale*** from Massey, Ont., 23.VI.36, show definite stigmal spots. Another collection of ***heterotarsale*** from Proctor, Minn., 20.VII.36 (unmeasured), is similar to the Massey series.

From the data given above, it is possible now to summarize tentatively the relationships of ***interpunctatum***, ***canadense***, and ***heterotarsale***. *S. **interpunctatum interpunctatum*** dwells in the Mississippi drainage. In the St. Lawrence drainage ***canadense*** is to be found. Both have their emergence peaks in the early summer; the early emergents are larger and darker than the seasonally later ones and this is especially true of the coloration of ***canadense***. Where the two populations meet, they probably intergrade, but it is impossible to tell a light ***canadense*** from a dark ***interpunctatum***. Also in the area around the Great Lakes, northern Indiana, Illinois, Ohio, New York, and along the St. Lawrence, there is a third population, ***heterotarsale***, that certainly intergrades with ***canadense*** and probably with ***interpunctatum***. This population reaches its peak of emergence at the end of the ***canadense-interpunctatum*** season. This has been noted by Ide on the Mad River, Ont., and shows clearly in the present study. Just what has kept and is keeping the ***heterotarsale*** population from completely amalgamating with the ***canadense-interpunctatum*** populations, it is impossible to say. Obviously there must be a definite survival value attached to each of the populations or they would quickly fuse into one variable one. Even so, there must be in nature an immense number of intergrading individuals. From present

TABLE II

MALE FORE WING LENGTH

PART I. Arrangement by Locality

Locality and Date	Total Spec.	Observed Range		M	σ	V	Estimated Range		Notes
		Max.	Min.				Max.	Min.	
Lachine Rapids, Que., 1-VII-38	23	19.50	15.25	17.02	0.97	5.70	19.93	14.11	All specimens
Same	16	18.75	15.25	16.68	0.90	5.70	19.38	13.98	Spec. with 0 and 1 abdomens
Same	6	17.75	16.25	17.00	0.48	2.80	18.42	15.58	Spec. with 2 abdomens. N-1 for det. of V.
Aylmer, Que., 26-VI-38	23	20.50	18.00	19.27	0.62	3.21	21.13	17.41	All spec. have Abd. and Th. 2 or 3
Louisville, Ky., 22-VIII-40; New Harmony, Ind., 30-V-40 and 16-VI-36	9	19.50	15.75	18.07	1.36	7.51	22.13	14.02	
As above except Louisville specimens omitted	6	19.50	18.00	18.97	0.55	2.90	20.63	17.32	
Sloatsburg, N. Y., 4-VI-33	12	24.00	19.50	21.46	1.40	6.51	25.66	17.26	Spec. 81 included; high V due to 83 and 87
Lexington, N. Y., 11-VI-38	12	22.00	19.50	20.83	0.88	4.19	23.45	18.21	
Bluffton, Ind., 20-VII-29	14	17.00	13.50	15.03	0.96	6.26	17.91	12.15	2 spec. have low tarsal ratio
Same	12	15.50	13.50	14.70	0.56	3.82	16.49	12.93	Spec. 136 and 139 omitted
Massey, Ont., 23-VI-36	5	17.50	19.00	18.32	0.57	3.10	20.03	16.61	N-1 used for determining σ

PART II. Arrangement by Taxonomic Category

Category*	Total Spec.	Observed Range		M	σ	V	Estimated Range		
		Max.	Min.				Max.	Min.	
canadense	26	9.95	8.28	8.96	0.39	4.34	10.13	7.79	
frontale	42	11.20	6.77	9.38	0.92	9.70	11.20	6.77	
interpunctatum	20	9.05	6.60	7.98	0.72	9.00	10.14	5.28	
heterotarsale	22	9.22	6.18	7.59	0.87	11.57	10.23	4.95	
gildersleevei	17	10.70	9.35	10.10	0.39	3.88	11.20	8.85	

*These figures are given in actual mm. while the locality figures are in eye-piece cross-hatch units; 20 cross-hatch units=9.35 mm. The high V is due to seasonal variation except for *canadense* which is probably too low because most of the 26 specimens belong to the Aylmer series. *S. gildersleevei* is an early season species whose emergence period is short.

data, it is not known just what is the exact range of any one of these populations. Apparently ***heterotarsale*** is not present in southern Ohio, Indiana, or Illinois, although a series from Amity, Ind., 2.VI.40, appears to be typical ***heterotarsale***. Individuals seen from southern Ohio, Indiana, and Illinois, and from Oklahoma, Missouri, and Kansas all belong to ***interpunctatum***. With considerable certainty, it can be said that ***heterotarsale*** does not overlap the entire ***interpunctatum*** range.

It is probable, but not definitely known, that a similar but obverse relationship exists in the distribution of ***heterotarsale*** and ***canadense***, i. e., that at the eastern and northern edges of the range ***canadense*** exists alone. There is, however, another population that meets with ***canadense***, namely ***frontale***. This seems to be the typical population of the lowlands of the Hudson River drainage and other eastern United States rivers. The holotype of this species was collected in the late summer (August). Emergents earlier in the season should be expected to be darker and probably larger. This is exactly what is found to be the case and these darker individuals are almost impossible to separate from ***canadense*** since the dark coloration tends to obscure the stigmal spots, etc., that differentiates ***frontale*** from ***canadense***. As indicated above, a series from Lexington, N. Y., 11.VI.38, which appears to be relatively typical ***frontale***, has a mean, a standard deviation and a coefficient of variation very close to those of ***canadense*** from Aylmer, Que. From Sloatsburg, N. Y., 4.VI.33, after a specimen of ***heterotarsale*** had been excluded, a series gave an M of 2.63 and a V of 12.60. These specimens have the facies of ***canadense***. Thus, while it is possible to separate ***frontale*** from light colored ***canadense***, it is impossible to tell typical ***canadense*** from dark ***frontale***. Probably true ***canadense*** extends down the Appalachian highlands but is replaced in the lowlands by ***frontale***.

The general conclusions as listed above have been based not only on tarsal ratio but also on wing length and the ratio derived from the ♂ fore wing length/first tarsal segment of ♂ fore leg length (called wing/tarsal ratio for short). These statistics support the tarsal ratio but are also of interest in their own right. Wing length (Table II) shows much less variation than does tarsal ratio, and thus has a lower coefficient of variation. A typical ***canadense*** (Table II), Aylmer, Que., series, has a wing length V of 3.21; ***frontale***, Lexington, N. Y., series, a V of 4.19; and ***interpunctatum***, New Harmony, Ind. (Louisville, Ky., specimens excluded) a V of 2.90. The series from the Lachine Rapids, Montreal, Que., displays a high V of 5.70 and when the lightly pigmented specimens (abdomens 0 and 1) are separated from the dark (abdomens 2) the V remains high for the light, but drops to 2.8 for the darker individuals. This is exactly parallel to what happened with the tarsal ratio. Note should be given that specimen No. 3 had broken wings and could not be included in the wing measurements. The Bluffton, Ind., series also shows a high V which drops when two long winged individuals are omitted. One of these, No. 136, is a light ***canadense*** individual that was considered in the tarsal ratio discussion. The other one, No. 139, however, has a ***heterotarsale*** type tarsal ratio. The Sloatsburg, N. Y., series displays a high V due to two specimens with long wings (No. 83 and No. 87) but No. 81, which was responsible

for the high tarsal ratio V has a wing of average length. The combined New Harmony-Louisville series of *interpunctatum* shows clearly the effect of seasonal variation. The Louisville specimens were collected later in the season than were the New Harmony specimens; although the New Harmony individuals were collected in different years, it was

TABLE III

RATIO OF $\frac{\text{MALE FORE WING LENGTH}}{\text{1ST SEGMENT } ♂ \text{ FORE TARSUS}}$ *

PART I. Arrangement by Locality

Locality and Date	Total Spec.	Observed Range		M	σ	V	Estimated Range		Notes
		Max.	Min.				Max.	Min.	
Lachine Rapids, Que., 1–VII–38	22	9.46	4.46	6.28	1.72	27.80	11.44	1.12	All specimens
Same	16	7.00	4.46	5.48	0.73	13.29	7.67	5.37	Spec. with 0 and 1 abdomens
Same	6	9.46	6.50	8.42	0.94	11.20	10.93	5.90	Spec. with 2 abd.; σ det. by N-I
Aylmer, Que., 26–VI–38	22	10.26	7.40	9.19	0.77	8.36	11.49	4.60	All spec. with thor. and abd. of 2 or 3
Louisville, Ky., 22–VII–40; New Harmony, Ind., 16–VI–36 and 30–V–40	9	11.70	9.25	10.57	0.75	7.10	12.82	8.37	σ det. by N-I
Sloatsburg, N. Y., 4–VI–33	12	11.19	6.50	9.26	1.37	14.95	13.37	5.15	
Lexington, N. Y., 11–VI–38	11	11.15	6.50	9.58	1.36	14.60	13.66	5.50	
Bluffton, Ind., 20–VII–29	9	11.20	3.66	6.41	2.75	42.70	14.86	2.04	See text

PART II. Arrangement by Taxonomic Category

Category	Total Spec.	Observed Range		M	σ	V	Estimated Range		
		Max.	Min.				Max.	Min.	
canadense	26	10.25	7.00	9.08	0.82	9.02	11.54	6.62	
interpunctatum	22	12.50	7.00	9.96	1.43	14.45	14.28	5.64	
frontale	33	13.50	6.50	9.37	1.52	16.40	13.93	4.81	
heterotarsale	21	6.50	3.50	5.48	0.88	16.14	8.13	2.82	

*This ratio was determined by dividing the scale ratio of the wing by the scale ratio of the tarsal joint.

at approximately the same time seasonally. Combined, the V is high due to the small size of the late-season Louisville specimens, but as soon as the Louisville series is removed the V drops. Finally, the Massey specimens, although only five in number, give a V of 3.10.

The wing length/first segment of the ♂ fore tarsus ratio (called for brevity the wing length/tarsal ratio) presents a picture similar to that

shown by the wing and tarsi separately. The co-efficient of variation shows greater range (Table III) than do those of the other measurements, varying from 7.10 for the *interpunctatum* specimens from Louisville and New Harmony to 42.70 for the Bluffton series. Actually, the latter series when plotted shows three distinct groupings: (1) Five specimens which show a ratio of 3.66 to 4.76—all of these specimens have "0" abdomens and thoraces. (2) Three specimens with ratios of 7.85 to 8.57—all three of these specimens (No. 136, No. 139, and No. 151) were considered in Tables I and II. (3) Finally, specimen No. 136, the most darkly pigmented specimen of the whole series, has a ratio of 11.20.

To supplement the picture of each valid subspecies, a series of typical individuals of every subspecies has been selected, utilizing individuals from all parts of the range and all emergence dates available. The statistics for these are given in Tables I, II, and III. Note also that the estimated range for each character has been determined by adding or subtracting 3 σ from the M. The coefficient of variability indicates that *canadense* is perhaps the least variable while *heterotarsale* and *frontale* are the most variable. The *canadense* figures are perhaps too low, due to the fact that the most of the specimens in the typical series of *canadense* came from the Aylmer series. The statistics for the other two subspecies are probably more reliable. As an added check to the validity of these findings, a number of specimens of *S. gildersleevei* have been measured and the statistics derived compared with those of the four subspecies. While they show less variability than any one of the four subspecies, the differences are not exceedingly great or beyond expectation since *S. gildersleevei* is a distinct, uniform appearing, geographically and ecologically restricted species.

In considering these series, the assumption has been made on the basis of coloration, size, markings, etc., that certain series, e. g., Aylmer, Lexington, Massey, and New Harmony represent samples drawn from populations that are sufficiently different to be allocated to different taxonomic populations. The same assumptions were made also for the series that was used to estimate the four subspecies. The statistics derived from these series show them all to have coefficients of variation that compare rather closely in magnitude and also compare closely with *Stenonema gildersleevei*, a distinct population for which ample and adequate evidence is available that it represents a different species. By utilizing the statistics derived from the two ratios and the wing length measurements, the question can now be studied as to whether, on the basis of these three characters at least, these various samples could have been derived from populations with the same means and variance, i. e., could they have come from one population? For this analysis, the following formulae were used:

1. $\sigma d = \frac{N_1}{N_2}\sigma^2 M_1 + \frac{N_2}{N_1}\sigma^2 M_2$ in which $\sigma M = \frac{\sigma}{\sqrt{N}}$
2. $D = M_1 - M_2$
3. $K = \frac{D}{\sigma d}$

The assumption is made that where $K<2$, the difference is not significant, i. e., the two samples could be drawn from the same populations. If $K>3$, the difference is significant, $K>2.5$ probably significant and $K>2$ possibly significant.

It can be seen (Table IV) that the Aylmer and Louisville plus New Harmony series are, on the basis of the tarsal ratio (K—2.30), possibly different, but that on the basis of wing length (K—1.08) the Aylmer and New Harmony series certainly do not have a significant K value. The

TABLE IV

VALUES FOR K

Locality and Date	2nd Tarsal Segment / 1st Tarsal Segment	Fore Wing	♂ Fore Wing Length / 1st Seg. ♂ Fore Tarsus
Aylmer, Que., 26-VII-38..... Louisville, Ky., 22-VIII-40 .....} New Harmony, Ind., 16-VI-36..}..... New Harmony, Ind., 30-V-40...}	2.30	1.08*	
Aylmer, Que., 26-VI-38 Lexington, N. Y., 11-VI-38	0.815	6.05	
Lexington, N. Y., 11-VI-38 Massey, Ont., 23-VI-36	8.17	6.68	
Lachine Rapids, Que., 1-VII-38 (spec. with abd. 0 and 1, No. 3 omitted); Same (spec. with abd. 2)	5.56	0.83†	
Taxonomic Category			
frontale *heterotarsale*	13.32	6.89	10.35
frontale *interpunctatum*	2.76	2.55	3.64
frontale *canadense*	0.48	1.52	1.34
heterotarsale *interpunctatum*	18.05	0.54	13.22
heterotarsale *canadense*	20.75	26.85	13.08
interpunctatum *canadense*	5.10	1.57	5.22

*Only New Harmony specimens involved (Louisville omitted), since seasonal variation of wing length would confuse picture.

†Specimen No. 3 included for wing measurements.

Aylmer and Lexington series have a significant K for wing length (6.05) but not for the tarsal ratio (0.815). With the Lexington and Massey series, the K is highly significant for both wing length and tarsal ratio. Most interesting is the Lachine Rapids series which, when divided on the basis of light abdominal coloration (0+1 for one series and 2 for the other) shows a significant K for the tarsal ratio but not for the wing length.

Turning to the various selected subspecies series, we find that only in the case of ***frontale*** and ***canadense*** is K of an insignificant value for all

three factors, i. e., tarsal ratio, wing/first tarsal ratio, and wing length. Obviously the two series studied could have come from the same population so far as these characters are concerned. For all the other pairs, at least one and more often all figures are significant, i. e., the samples could not have been drawn from the same population. It must be remembered that these figures apply only to certain characters and that there may be other characters which will clearly separate and distinguish the two populations under consideration.

On the basis of all the data available, there seem to be four distinct populations and the names *canadense*, *frontale*, *interpunctatum*, and *heterotarsale* legally and logically apply to these groups. All evidence, both qualitative and quantitative, indicate that these four populations are subspecies. Three of these subspecies (*canadense*, *frontale*, and *interpunctatum*) are definitely geographical subspecies, but the fourth (*heterotarsale*) may at present be separated from the other three ecologically rather than geographically, since it dwells in at least part of the range of all three other subspecies. *Canadense*, *frontale* and *interpunctatum* all reach the peak of their emergence in the late spring and early summer, while *heterotarsale* reaches its peak of emergence much later in the summer. Further, *heterotarsale* nymphs need a different type of environment than does *canadense*, e. g., *heterotarsale* lives in the lower reaches of a stream and *canadense* lives further up the stream. This indicates that there are considerable physiological differences between the nymphs of at least these two subspecies. Certainly there must be strong selective action being applied to keep these two subspecies distinct, or they long ago would have fused into one highly variable population. Probably this selective pressure is exerted upon the nymphal rather than the adult populations.

Just how the present distribution of the four subspecies arose is not completely clear, but at least part of the history since the Pleistocene glaciation can be hypothesized. At the time of the glaciation, probable *canadense* was the highland, cool stream form of the east with a closely related *frontale* population occupying the lowlands of the eastern coastal area. In the Mississippi Valley, an *interpunctatum* population emerging early in the summer dwelled in the southern lowlands with a *heterotarsale* population further to the north, a population that emerged later in the season than *interpunctatum*. When the glacier retreated, *canadense* moved north and also west along the Great Lakes, while *heterotarsale* also invaded the same area but at lower elevations. Thus, the present Great Lakes and their glacial predecessors served as a broad highway for the distribution of these two subspecies and, due to different ecological demands, they were able to live in the same geographical area and still maintain their integrity. The Atlantic coastal dwelling *frontale* stock was faced, when the glacial ice melted and the level of the ocean rose, with a much reduced territory while the "warm water" *interpunctatum* followed behind *heterotarsale* and eventually came into contact not only with *heterotarsale* but also with *canadense* which had geographically interdigitated with *heterotarsale*. In this area, there is the confusing picture resulting actually from the interbreeding of three populations. It is from this mixed population that

the greater majority of the species which have been synonymized have been derived, for with the exception of *pallidum*, the types of all these species were collected in this area.

BIBLIOGRAPHY

Clemens, W. A. 1913. Canad. Ent., vol. 45: 246–262, 329–341.
Morgan, Anna H. 1913. Ann. Ent. Soc. Amer., vol. 6: 371–413.
Lameere, A. 1922. Bull. Class. des Sci. Acad. Roy. Belgique, vol. 38: 149.
Clemens, W. A., and **A. K. Leonard.** 1924. Canad. Ent., vol. 56: 17–18.
Ide, F. P. 1935. Canad. Jour. Res., vol. 12: 433–478.
1935. Ont. Fish. Res. Lab. Pub., 50: 9–74.
Needham, Traver, Hsu, etc. 1935. Biology of Mayflies. Ithaca, N. Y.
Spieth, H. T. 1938. Canad. Ent., vol. 70: 210–218.
Ulmer, G. 1939. Arch. Hydrobiol. Suppl., 16: 443–580.
1940. Arch. Hydrobiol. Suppl., 16: 581–692.
Kimmins, D. E. 1941. The Entomol,, vol. 74: 169–170.

APES, GIANTS AND MAN, by FRANZ WEIDENREICH. Pages vii+122, 1946. The University of Chicago Press. Price $2.50.

For many years our knowledge of the evolution of man was derived from the logical analysis of his relation to the other primates, supported by rather meager evidence from a few significant fossil remains. *Pithecanthropus erectus*, the ape-man of Java, was the one striking primitive ancestor, while Heidelberg man, Neanderthal man and Cro-Magnon man were transitional early human forms. The actual link with more primitive anthropoid stock was lacking and the precise relations of anthropoid and human ancestral lines was therefore uncertain. Well before the second World War the discovery of *Sinanthropus pekinensis* in China added considerably to our knowledge of the level of human evolution previously illustrated only by *Pithecanthropus*, but left the same gap between man and his anthropoid precursors.

Weidenreich's book discusses impressive additions to this fossil record which might have been made known earlier but for the intervention of the war. Java and China again are the sources of the important remains. *Gigantopithecus* from China and *Meganthropus* from Java fill the all-important gap as manlike creatures still more primitive than *Pithecanthropus* and *Sinanthropus*. They are interpreted as human remains, but of such primitive characteristics that they indicate the actual transition from the anthropoid ancestral line.

With these additions the author is enabled to offer a very convincing explanation of the evolution of the primates. As early as the Miocene the simiid stock apparently began its differentiation, giving rise to one line of descent represented by the fossil *Dryopithecus* which was possibly ancestral to the existing Simiidae and to another which produced the australopithecine forms and the human species. The gibbons probably diverged at an even earlier period. The combination of simiid and human characteristics in *Australopithecus* leads to the conclusion that these creatures were an isolated branch which became extinct without contributing to the formation of any existing species. In the human line of descent *Gigantopithecus*, *Meganthropus*, the pithecanthropine forms and the sequence of human remains form a sufficiently connected series to tax the debating capacity of the fundamentalists. They leave no reasonable doubt of the gradual transition already established, although they introduce another consideration in the apparent reduction of size as modern man has evolved.

The book is technical but not too technical. It arouses admiration even in a scientific mind of the detailed precision with which the physical anthropologists can interpret the meager remains of some of these early species and presents the results comparatively in a most clear and convincing form. It necessitates some revision of earlier concepts, particularly in the evolution of the brain, but even in such points it gives the impression of conservative judgment and dependability.

The author predicts a rich future in the pursuit of investigations in the Oriental region. We can only hope that he will not be impeded in the work now that the war is over and that before many more years have passed we may have other contributions from his pen.—A. W. L.

NOTES AND KEYS TO THE NEUROPTERA OF MISSOURI

RICHARD C. FROESCHNER

The Neuroptera of Missouri have never been treated as a unit. In fact, our card catalogue of Missouri insects contains literature records for only seven of the thirty-seven species here recorded for the state. The probable occurrence of six more species raises our grand total for the order to forty-three species. Undoubtedly some species not considered here will eventually be found in the state and raise the number still higher. However, we have found from experience with other groups that by the time three-fourths of the probable list has been accumulated, additions are very slow in appearing and further delay in preliminary publication gains very little. Therefore, we are publishing this with the hope that it will not only make our findings available to others, but will also lay the groundwork for more intensive study by other students in the state.

As is usual in this kind of a study, one relies on the work of others to supplement his own. In accumulating records I have had the co-operation of the following men who have kindly granted me use of collections in their care: Dr. L. Haseman of the University of Missouri, and Mr. J. A. Denning of the State Department of Agriculture. In addition, Dr. E. P. Meiners and Messrs. W. S. Craig, W. R. Enns, C. C. Goff and H. I. Rainwater have allowed me access to their personal collections. To all these men I am sincerely grateful.

Records of all data for which I am not personally responsible are indicated by the collector's initials, as in the following list: C. C. Goff, C. W. Wingo, E. H. Froeschner, E. P. Meiners, G. J. Jones, H. I. Rainwater, R. I. Wakeman, W. K. Clark, W. Murray, W. R. Enns, W. S. Craig and W. W. Smith.

For technical help with some of the problems I am deeply obliged to Dr. F. M. Carpenter of Harvard University, Dr. E. A. Chapin of the National Museum and Dr. R. C. Smith of Kansas State College.

The illustrations were done by my wife, Elsie Herbold Froeschner. The full figures as well as the wing of *Mantispa* are all original. The rest of the wings were redrawn from other authorities, as follows: Banks 1907—*Conwentzia*, 1927—basal parts of Myrmeleontid wings; Carpenter 1940—*Boriomyia*, *Lomamyia* and *Sisyra;* Comstock 1936—*Sympherobius*, *Chrysopa*, *Myrmeleon* and *Ululodes*.

All the difficult venational characters are graphically explained by these figures. However, one character might be profitably explained. The gradate veins are cross-veins which are usually arranged in one or two transverse series across the wings—an outer series near apical fourth and an inner series nearer the middle—as best seen in fig. 12. The number in each series may be greatly reduced and may not form such a regular series or they may be entirely absent.

KEY TO THE MISSOURI FAMILIES OF NEUROPTERA

1. Prothorax longer than broad; fore legs fitted for grasping, i.e., femora swollen and with prominent spines and teeth on lower margin, **Mantispidae**
Prothorax shorter than broad; legs simple 2
2.(1). Antennae either gradually enlarged toward apex or filiform with a distinct terminal knob 3
Antennae simple and filiform; females without an exserted ovipositor 4
3.(2). Antennae not or only very slightly longer than head plus thorax; wings with a greatly elongated cell immediately behind junction of Sc and R_1 (Fig. 17) ..... **Myrmeleontidae**
Antennae at least three-fourths as long as the entire length of the body; cell behind junction of Sc and R_1 not elongated (Fig. 15) ..... **Ascalaphidae**
4.(2). Wings with numerous costal cross-veins (Figs. 9–13), but not covered with a whitish powder; length more than 5 mm 5
Wings without a series of costal cross-veins (Fig. 14), but covered with a whitish powder; length not over 4 mm ..... **Coniopterygidae**
5.(4). Two or more branches of Rs arising from apparently fused stem of R_1 and Rs in front wings (Fig. 12) ..... **Hemerobiidae**
All branches of Rs arising from a single Rs stem (Fig. 13) 6
6.(5). Costal cross-veins forked in fore wings (Fig. 9) ..... **Berothidae**
Costal cross-veins not forked in fore wings 7
7.(6). Sc and R_1 fused before reaching margin of wing (Fig. 13); gradate veins absent (Fig. 13) ..... **Sisyridae**
Sc and R_1 extending separately to margin of wing (Fig. 11); gradate veins present (Fig. 11) ..... **Chrysopidae**

Family **Mantispidae**

KEYS TO MISSOURI GENERA AND SPECIES

1. Radial cells long and narrow, especially the basal two; anterior half or more of wings distinctly clouded with fuscous ..... I. **Climaciella**
Radial cells short, basal two relatively broad; wings never clouded with fuscous as above ..... II. **Mantispa**

I. **Climaciella** Enderlein

1. Color brown, usually distinctly marked with yellow; all wings with anterior half or more covered by a brownish cloud; anal vein of fore wing branched; length of fore wing 10–12 mm ..... 1. **brunnea**

II. **Mantispa** Illiger

1. Fore wings with one fuscous spot near apex and two just behind R_1 just posterior to stigma; length of fore wing 9–20 mm ..... 2. **interrupta** (Fig. 8)
Fore wings without fuscous spots; length of fore wing 12–15 mm ..... 3. **sayi**

NOTES ON MISSOURI MANTISPIDAE

1. *Climaciella brunnea* (Say). This species is rare in local collections. A single individual was found in a dense weed growth along a stream bank through a woods near St. Louis on July 13. Malt-baited codling moth traps yielded several specimens in Lawrence County during July (WWS).

2. *Mantispa interrupta* Say. This species has been swept in some numbers from isolated oak trees and from along edge growth adjacent to oak woods. Adult records extend from June 14 to September 26. Buchanan, Boone, Jefferson, (EPM), Johnson, Macon, Oregon, Ste. Genevieve and Vernon counties.

3. *Mantispa sayi* Bks. A lone individual was taken from malt-baited codling moth traps in Lawrence County on June 6 (WWS).

1. *Lomamyia banksi*, ×2. 2. *Hemerobius humulinus*, ×3. 3. *Hesperoleon abdominalis*, ×1. 4. *Climacia areolaris*, ×3. 5. *Conwentzia hageni*, ×4. 6. *Colobopterus excisus*, ×1. 7. *Chrysopa nigricornis*, ×2. 8. *Mantispa interrupta*, ×1½.

Family **Myrmeleontidae**

KEYS TO MISSOURI SUBFAMILIES, TRIBES, GENERA AND SPECIES

1. Fore wing with A_2 forming a fairly even curve and connected to A_3 by a short cross-vein or united to it for a short distance (Figs. 18 and 19). Dendroleoninae 2
   Fore wing with A_2 beginning and extending close up to A_1 and then turning sharply down to join A_3 (Fig. 20) 4
2.(1). Tarsal I at least as long as II plus III; Cu of fore wing united to A_1 by a short, oblique fork (Fig. 19). Dendroleonini ..... I. **Dendroleon**
   Tarsal I shorter than II plus III; Cu of fore wing not connected to A_1. Brachynemurini 3
3.(2). Tibial spurs absent ..... II. **Cryptoleon**
   Tibial spurs present; costal area of fore wing with but one series of cells on basal half; front femora without rows of bristles above, III. **Hesperoleon**
4.(1). Hind wing with but one, or rarely two cross-veins before origin of Rs, latter point before cubital fork. Macronemurinae 5
   Hind wing with four or more cross-veins before origin of Rs, the latter usually beyond cubital fork (fig. 17); tarsal I longer than broad; tarsal claws scarcely curved. Myrmeleoninae ..... VI. **Myrmeleon**
5.(4). Hind wing with a large, dark spot near apex; legs slender; femora cylindrical ..... IV. **Glenurus**
   Hind wing without large spot near apex; legs stout, femora slightly thickened ..... V. **Psammoleon**

I. **Dendroleon** Brauer

1. Both front and hind wings marked with conspicuous brown spots and blotches; fore wing 25–31 x 7–8.8 mm ..... 4. **obsoletum**

II. **Cryptoleon** Banks

1. Costal area of fore wing with a single row of cells throughout most of its length; wings very lightly marked, not maculate between Sc and R; fore wing 20–23 x 5.2–6 mm ..... 5. **signatum**

III. **Hesperoleon** Banks

1. Pronotum with broad, entire, brown median line; tibial spurs not reaching apex of tarsal I; fore wing 21 x 5–7 mm ..... 6. **irregularis**
   Pronotum with median brown stripe divided medially by a pale stripe; tibial spurs as long as tarsals I plus II; fore wing 21–27 x 5–7 mm., 7. **abdominalis** (Fig. 3)

IV. **Glenurus** Hagen

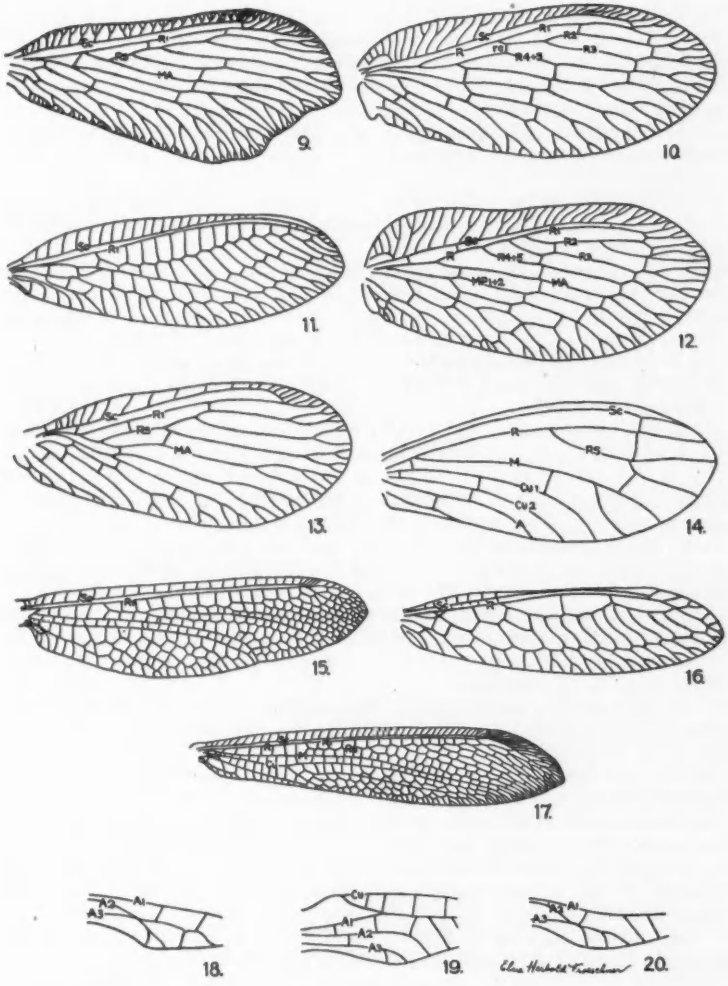
1. Extreme tips of wings dark; subapical area of fore wing whitish with a rosy tint; legs dark; fore wing 34–47 x 9–15 mm ..... 8. **gratus**

V. **Psammoleon** Banks

1. Tarsi and mid and hind femur in part pale; tibial spurs longer than tarsals I plus II; fore wings with two dark, nearly parallel streaks; fore wing 29–31 x 6–7.5 mm ..... 9. **guttipes**

VI. **Myrmeleon** Linnaeus

1. Cells between R_1 and Rs much longer than cells behind the Rs; fore wing 22–36 x 5.8–8 mm ..... 10. **immaculatus**
   Cells between R_1 and Rs equal to or subequal to those behind Rs (Fig. 17); veins dotted 2
2.(1). Rs arising but slightly beyond fork of Cu; clypeus entirely pale; lateral lobes of pronotum at least partly dark; fore wing 22–35 x 5.8–8 mm., 61. **mobilis**
   Rs arising much beyond fork of Cu; marks on clypeus and all of vertex and mesonotum dark; fore wing 22–29 x 4.9–7 mm ..... 12. **crudelis**



9. Fore wing of *Lomamyia*. 10. Fore wing of *Sympherobius*. 11. Fore wing of *Chrysopa*. 12. Fore wing of *Boriomyia*. 13. Fore wing of *Sisyra*. 14. Fore wing of *Conwentzia*. 15. Fore wing of *Ululodes*. 16. Fore wing of *Mantispa*. 17. Fore wing of *Myrmeleon*. 18, 19, 20. Characters in anal area of fore wings of Myrmeleontidae.

4. *Dendroleon obsoletum* (Say). Just two specimens of this species are at hand from Missouri. One was collected in Oregon County (WKC) and the other was found dead on a window sill in an abandoned building in St. Louis. Hagen (1861) lists it for "St. Louis" under the generic name *Myrmeleon*.

5. *Cryptoleon signatum* (Hag.). With a recorded range that extends as far west as central Illinois, this species forms a "probable" for our fauna.

6. *Hesperoleon irregularis* (Curr.). This species has been recorded to both the east and west of us in Illinois and Kansas and so will undoubtedly be found to occur in Missouri.

7. *Hesperoleon abdominalis* (Say). This is by far the most common of the Missouri Myrmeleontidae. Adults of this poor, low-flying species are to be encountered along roadsides, in weedy fields, at edges of woods and along stream banks between June 10 and August 18. Adair (EHF), Buchanan (RIW), Carter, Henry, Mississippi, Morgan, Nodaway, Oregon, Perry (EHF), Pike (WSC), St. Louis, Schuyler and Stoddard counties.

8. *Glenurus gratus* (Say). Dr. E. P. Meiners collected numerous specimens at rest on tree trunks in a woods in St. Louis County on July 5, 12, 29, 30 and 31. Hagen (1861) listed this for "St. Louis" under the generic name *Myrmeleon*. Banks (1892) placed it, with some doubt, in the genus *Dendroleon* and recorded it for "Mo."

9. *Psammoleon guttipes* Bks. Of the two available Missouri specimens, only one has full data. It was collected in Miller County on August 16.

10. *Myrmeleon immaculatus* DeG. Our adult specimens were all collected in the period between May 23 and September 15. Rau (1926) records it for "Wickes" in Jefferson County. Boone, Lawrence, St. Louis and Taney counties.

11. *Myrmeleon mobilis* Hag. This species, which Banks lists only from Alabama and Georgia, is included in our list on the basis of a record by Rau (1926). The material, which was collected in Jefferson County, was identified by Caudell, apparently at the same time that he determined the more common *M. immaculatus* for Rau. This seems to indicate that there were two species involved so this might possibly be correct. Dr. Chapin, in kind reply to my request, searched through the National Museum's series of this genus but could find no Rau material there. Final confirmation of the Missouri occurrence of this species now becomes a problem for future collecting.

12. *Myrmeleon crudelis* Wlk. One specimen was swept from a woods near the Lake of the Ozarks in Camden County on June 21.

Family **Ascalaphidae**

KEYS TO THE MISSOURI GENERA AND SPECIES

1. Eyes entire, not divided by a horizontal groove.....I. **Neuroptynx**
   Eyes divided by a horizontal groove..... 2
2.(1). Hind wing with posterior margin suddenly and deeply emarginate at basal fourth (Fig. 6).....II. **Colobopterus**
   Hind wing with posterior margin gently sloping to base, not suddenly emarginate.....III. **Ululodes**

I. **Neuroptynx** McLachlan

1. Front wing with a strong thumb-like projection near base of hind margin, 13. **appendiculatus**

II. **Colobopterus** Burmeister

1. Antennae not reaching beyond stigma; wings clear hyaline; forewing 28–30 x 8 mm.....14. **excisus** (Fig. 6)

III. **Ululoides** Currie

1. Antennae reaching or surpassing apex of wings; stigma black; fore wing 25–29 x 6.5–7.5 mm.....15. **macleayana hageni**
Antennae not surpassing stigma; stigma milky-white or yellow; fore wing 29–32 x 7–8 mm.....16. **quadrimaculata**

NOTES ON MISSOURI ASCALAPHIDAE

13. *Neuroptynx appendiculatus* (Fab.). But a single Missouri specimen was seen during this study. It was collected in Jefferson County on July 7 (EPM).

14. *Colobopterus excisus* Hag. Of the several specimens that have passed through my hands during this study, only one had any ecological data attached. That one was collected "at lights" (WWS). However, it should not differ in habits from the other members of the family. Adult records at hand extend from June 11 to August 2. Buchanan (CCG), Jefferson (EPM), Lawrence (WWS), and Oregon (WKC) counties.

15. *Ululodes macleayana hageni* Weele. Under a synonym, *U. hyalina* (Latr.), this species is listed by Knetzger (1908) as having been taken in St. Louis during July. We have no specimen-records, but it is undoubtedly a member of our fauna.

16. *Ululodes quadrimaculata* (Say). Although most of the adult specimens were taken while sweeping low branches of isolated trees or in open woods, one was observed at rest in the position so characteristic of this family: body resting lengthwise to the perch, wings held roof-wise and antennae extended straight forward. One larva of this was found on the surface of open rocky soil on an Ozark hill. When disturbed it brought its legs in close to its body, opened its mandibles widely and "played dead." This larva was collected in early October and held out-of-doors during the winter. On April 19 it spun a small, white, silken cocoon and pupated. The imago emerged almost two months later on June 5. Adults have been found from April 23 until July 19. Boone, Carter, Franklin (WRE), St. Louis and Stone counties.

Family **Hemerobiidae**

KEYS TO MISSOURI GENERA AND SPECIES

1. Fore wing with an arcuate or recurrent vein in basal costal area (Figs. 10 and 12)..... 2
Fore wing without a recurrent vein in basal costal area, costal margin abruptly narrowed basally.....IV. **Micromus**

2.(1). Fore wing with no more than four gradate veins in outer series (Fig. 10), I. **Sympherobius**
Fore wing with five or more gradate veins in outer series..... 3

3.(2). Fore wing with a cross-vein between MA and MP_{1+2} shortly after the origin of the latter (Fig. 12).....II. **Boriomyia**
Fore wing without such a cross-vein.....III. **Hemerobius**

I. **Sympherobius** Banks

1. Fore wing with vein rc present (Fig. 10)..... 2
Fore wing without vein rc, its maculations consisting of small, irregular spots distributed rather uniformly over the entire surface; costal area very broad; fore wing 3.5–5.1 x 1.5–2.1 mm.....20. **barberi**

2.(1). Vein rc connecting R_{4+5} to $R_{1+}Rs$ before the origin of R_{2+3}; wings brownish, cells margined with darker brown; fore wing 5 x 2 mm...17. **occidentalis**
Vein rc connecting R_{4+3} to R_{2+3} (Fig. 10)..... 3

3.(2). Wings brown, veins unicolorous and narrowly bordered in cells with hyaline; antennae with basal third yellowish, remainder fuscous; fore wing 4–5 x 1.6–2.5 mm.....18. **umbratus**
Cells of fore wings milky to hyaline, strongly mottled with brown; veins light with a black point at base of each hair; fore wing with basal hind angle and an irregular band across inner series of gradate veins dark brown to black; antennae with basal third blackened, remainder pale; fore wing 3.5–6 x 1.3–2 mm.....19. **amiculus**

II. **Boriomyia** Banks

1. Two transverse brown bands on each fore wing, one across each of the two series of gradate veins; fore wing 4 x 7 mm.....21. **fidelis**

III. **Hemerobius** Linnaeus

1. Median longitudinal pale stripe of pronotum nearly or quite as broad as width of head between eyes; fore wing 6.5–8.5 x 3–3.5 mm., 22. **humulinus** (Fig. 2)
Median longitudinal pale stripe of pronotum reduced to a very narrow line or entirely absent; fore wing 7.5–8 x 3 mm.....23. **stigmaterus**

IV. **Micromus** Rambur

1. Fore wings with inner gradate veins much more than their lengths apart; vertex, pronotum and wings medium to light brown; fore wings 7 x 2.3 mm.....24. **subanticus**
Fore wings with inner gradate veins never more than their lengths apart, the fourth distad of third; fore wing 9 x 4 mm.....25. **posticus**

NOTES ON MISSOURI HEMEROBIIDAE

17. *Sympherobius occidentalis* (Fitch). On July 19 a single specimen was collected while at rest on the shaded trunk of an elm tree in Scott County.

18. *Sympherobius umbratus* (Bks.). This species has been previously reported only from Arizona and New Mexico. Our single specimen, a female, was collected in general sweeping along the edge of a woods in Cole County on June 21. Verification of this determination was kindly made by Dr. Carpenter who remarked that even though it was impossible to check male genitalia he thought it was undoubtedly this species.

19. *Sympherobius amiculus* (Fitch). This species shows a decided preference for red cedar, *Juniperus virginiana* L., at least the majority of our specimens were collected from trees of that species. Extremes of adult records at hand are April 8 and August 7. Boone, Cape Girardeau, Iron, Ste. Genevieve and St. Louis counties.

20. *Sympherobius barberi* (Bks.). Adults appear to be common from May 13 until July 4. However, we do have a single record for mid-September. Boone, Cole, Crawford, Iron, Laclede, Phelps, Randolph and St. Louis counties.

21. *Boriomyia fidelis* (Bks.). This species has been listed for as far west as southern Illinois and Texas and so probably will be found in Missouri.

22. *Hemerobius humulinus* Linn. Our adult records fall into two groups, one from April 6 until July 7 and the other from September 18 to October 16. They are common during both periods. This may indicate two generations a year or it may indicate hibernation in the adult stage. Boone, Butler, Carter, Cole, Iron, Laclede, Lawrence (WWS), Ste. Genevieve, St. Louis (EHF), Saline and Schuyler counties.

23. *Hemerobius stigmaterus* Fitch. The four specimens studied were dated April 1 and 18, May 6 and October 10, indicating that this species may hibernate as adult. Banks (1905) records a specimen from "Central Mo." Boone and St. Louis counties.

24. *Micromus subanticus* (Wlk.). The few available adult records extend from June 24 until August 2. During June several specimens were found in the base of a grass clump. Instead of attempting to escape by flight they ran into the clump or tumbled to the ground and feigned death. Boone, Howell, Jasper and St. Louis counties.

25. *Micromus posticus* (Wlk.). More common than its congener, this species appears to occur throughout the year, our records being for March, June, July, August, September, October and December. Hibernating individuals have been found in crumpled dead leaves which were still hanging to the trees and among dead leaves on the ground. Bollinger (CWW), Boone, Cape Girardeau (CWW), Greene (HIR), Jefferson, Platte, St. Louis, Scott and Stone counties.

Family **Berothidae**

KEYS TO MISSOURI GENUS AND SPECIES

1. Hind wing with but three gradate veins, the lower one in line with the other two; fore wing with lower gradate vein of outer series not more than its length from the one above it.....I. **Lomamyia**

I. **Lomamyia** Banks

1. Males (without prominent external genitalia) with face reddish-brown and aedeagus s-shaped; females (with prominent external genitalia) with a patch of black scales on anterior face of fore coxa; fore wing 10 x 4.2 mm.....26. **banksi** (Fig. 1)

NOTES ON MISSOURI BEROTHIDAE

26. *Lomamyia banksi* Carp. A female was swept from a red cedar tree, *Juniperus virginiana* L., on May 3. A male was collected by sweeping low, weedy growth in an oak woods on August 1. Oregon and Washington counties.

Family **Sisyridae**

KEYS TO MISSOURI GENERA AND SPECIES

1. Rs of fore and hind wings with but one main fork, and that below the stigma; fore wings marked with brown or black.....I. **Climacia**
   Rs of fore and hind wings with two main forks, both much before the stigma (Fig. 13); fore wings uniformly colored.....II. **Sisyra**

I. **Climacia** McLachlan

1. Antennae dark brown; head and legs light yellow; fore wing with a spot at apex of stigma, an oblique patch from base of stigma to Rs and one at base between Sc and R dark brown, these sometimes so reduced as to be only indicated by darkening of the veins in these areas; fore wing 5 x 2 mm.....27. **areolaris** (Fig. 4)

II. **Sisyra** Burmeister

1. Head yellow to brown; thorax yellowish-brown to medium brown, abdomen brown; fore wing 6 x 2.5 mm.....28. **vicaria**

NOTES ON MISSOURI SISYRIDAE

27. *Climacia areolaris* (Hag.). A lone specimen was collected in Taney County on September 15. Its venation differs slightly from that in the wing figured by Carpenter (1940) in that the main fork of Rs occurs basad of the position indicated. In ours it occurs below the proximal end of the stigma. In addition, the wing markings are greatly reduced, being merely suggested by blackening of the veins in the areas on which the maculations are pictured.

28. *Sisyra vicaria* Wlk. Two specimens were taken in a cypress swamp in Dunklin County on May 12. It should be found throughout most of the state.

Family **Chrysopidae**

KEYS TO MISSOURI GENERA AND SPECIES

1. Color predominantly brown to dark reddish-brown; veins of wings spotted with brown; hind wings with one series of gradate veins...I. **Eremochrysa**
Color green, yellow-green or yellow; wing veins not spotted; antennae separated by a space which is narrower than the width of basal antennal segment..... 2
2.(1). Stigma prominently marked with purplish dots.....II. **Nodita**
Stigma not dotted with purplish or brown.....III. **Chrysopa**

I. **Eremochrysa** Banks

1. Transverse veinlets of wings alternately spotted with light and dark areas.....29. **punctinervis**

II. **Nodita**

1. Bases of antennae not reddish above; gradate series converging posteriorly, the inner one of five veins.....30 **americana**

III. **Chrysopa** Leach

1. Antennae black on basal half, except segments I and II..... 2
Antennae pale with a dark ring on II or pale throughout..... 3
2.(1). Pronotum not marked with red laterally; antennal I entirely pale..... 3
Pronotum with a longitudinal red line near lateral margins; antennal I with a black stripe above; vertex not marked with black; fore wing 15 x 7 mm.....33. **lateralis**
3.(2). Clypeus with a black dot on each side; stigma indistinct; fore wing 11–16.5 x 3.5–5.8 mm.....31. **nigricornis** (Fig. 7)
Clypeus without black spots; stigmata brownish on all wings, 32. **columbiana**
4.(1). Antennal II with a dark ring; face with an extensive black pattern; fore wing 11–13.7 x 4–5.8 mm.....34. **oculata**
Antennae entirely pale; face with little or no black..... 5
5.(4). All veins, including cross-veins, pale..... 6
Many of the cross-veins fuscous-black or marked with fuscous black..... 7
6.(5). Genae with a black or dark brown band from lower margin of eye to base of mandible, sometimes also suffused with red; fore wing 10–12.8 x 3.3–4.1 mm.....35. **plorabunda**
Genae broadly suffused with red but without a black band between eye and base of mandible; fore wing 11–12.8 x 3.7–4.1 mm....36. **harrisii**
7.(5). Genae without a colored band between lower margin of eye and base of mandible; fore wing 11–12 x 4 mm.....37. **intacta**
Genae with a red band between lower margin of eye and base of mandible... 8

8.(7). Orange spotting as follows: sometimes a pair on vertex near eyes, at least two pair on pronotum, several on mesonotum and along sides of abdomen; fore wing 9.5–14.5 x 3.1–5.2 mm.....38. **quadripunctata**
No orange spotting on head, thorax or abdomen; radial and costal cross-veins black in middle and green at ends..... 9
9.(8). Color straw yellow with no median, yellow, dorsal stripe indicated; gradates and many other veins marked with black; fore wing 10.4–11 x 3.1–3.5 mm., 39. **interrupta**
Color green or greenish-yellow with a yellow, median, dorsal stripe which is usually distinct; usually only gradates blackened; fore wing 11–11.4 x 3.7–4 mm.....40. **rufilabris**

NOTES ON MISSOURI CHRYSOPIDAE

29. *Eremochrysa punctinervis* (McLach.). This species has been listed for Oklahoma, Kansas, Nebraska and Iowa and so should be found in Missouri.

30. *Nodita americana* (Bks.). Further collecting in Missouri might find this rare species which was described from Alabama and subsequently listed for Kansas and Texas.

31. *Chrysopa nigricornis* Burm. This uncommon species, which occasionally comes to lights, has been collected as adult during April, May, June and September. Boone, Miller, St. Louis, Schuyler (EHF) and Stoddard counties.

32. *Chrysopa columbiana* Bks. No Missouri specimens of this have been noticed in the material which has passed through the author's hands. It has, however, been listed as occurring in Canada, Iowa and North Carolina and so some day may be found in Missouri.

33. *Chrysopa lateralis* Guer. A single specimen was collected in Stoddard County on August 11.

34. *Chrysopa oculata* Say. Between May 3 and October 7, this species, with its numerous color varieties, has proven itself to be the commonest Chrysopid in the State. It is chiefly an inhabitant of fields, gardens and even city lots. It comes freely to lights. The following color forms, which may be separated in the key given below, have already been noted in the available Missouri material: nominal *oculata* Say, *separata* Bks., *chlorophana* Burm. and *illepida* Fitch.

KEY TO COLOR FORMS OF CHRYSOPA OCULATA SAY

a. Gradates and usually some of the cross-veins of wings at least in part black..... b
Gradates and cross-veins of wings (except some of costal cross-veins in hind wings) light or green; wings broad and rounded at tips...**chlorophana**
b.(a). Black loops under antennae not connected to marks on genae beneath eyes or connection very faint.....**separata** Bks.
Black loops under antennae distinctly connected with marks on genae.... c
c.(b). Vertex either wholly yellow or with a pair of short, longitudinal black dashes..... d
Vertex with four separate blackish spots and usually another one behind each compound eye..... f
d.(c). Vertex without any dark spots or only small ones in reddish band above the antennae..... e
Vertex with a pair of short, elongate dark lines which are usually connected with reddish band above antennae.....**illepida** Fitch
e.(d). No spots at all on vertex.....**carei** Sm.
Vertex with small black or brown spots in close connection with the reddish band above the antennae.....**xanthocephala** Fitch
f.(c). Most cross-veins brown or black.....**albicornis** Fitch
Costal cross-veins darkened only at ends, most cross-veins pale..**oculata** Say

As indicated by the following list of counties in which it has been collected, this species can be expected to be found throughout the state: Bollinger, Boone, Buchanan, Butler, Carter (EHF), Chariton (EHF), Clark, Crawford, Dallas, Daviess, Dunklin, Harrison, Holt, Howard, Iron, Jackson, Jasper, Jefferson, Laclede, Lawrence (WWS), Linn, Macon, Mississippi, Newton, Pemiscot, Perry, St. Louis, Scott, Shannon, Stoddard, Stone and Taney counties.

35. *Chrysopa plorabunda* Fitch. The adults of this common species hibernate. They may be found clinging to dried leaves that remain on the plants or among debris on the ground. In the active season they prefer open fields and are to be collected along with *oculata*. We have adult records for every month in the year. C. V. Riley (1870 and 1875) lists it for "Allenton" in St. Louis County. In addition to the nominal form, the variety *californica* Coq. has been found among the material reviewed. These two forms may be separated by the following couplet:

Little or no red bordering the narrow black bands on genae, nominal **plorabunda** Fitch

Considerable reddish suffusion along the black bands and extending over genae and sides of clypeus.....variety **californica** Coq.

Adair, Boone, Buchanan, Cass, Cole, Crawford, Dade, Franklin, Harrison (EHF), Jackson, Jefferson, Lawrence (WWS), McDonald (EHF), Macon, Maries, Miller, Nodaway, Osage, Phelps, Pike, Pulaski, Ste. Genevieve, St. Louis, Saline (EHF), Shannon and Taney counties.

36. *Chrysopa harrisii* Fitch. To date, only the nominal form of this species has turned up in the material studied. It is uncommon and has been collected during June, October and early November. McDonald, Pulaski and Schuyler (EHF) counties.

37. *Chrysopa intacta* Nav. The specimens here placed under this name agree rather well with Smith's (1932) translation of the original description, except that the color is yellowish rather than greenish. As Smith says, this is a "very general description" which results in a poorly defined species. However, since our specimens fit it better than any other, especially in the absence of a colored band between lower margin of eye and base of mandible, I am leaving them under this name. The extremes of dates are June 20 and July 21. Newton, Pemiscot, Reynolds and St. Louis counties.

38. *Chrysopa quadripunctata* Burm. The Missouri specimens at hand were collected during July and September in Nodaway, Scott, Stoddard and Vernon counties, indicating a widespread distribution in the state.

39. *Chrysopa interrupta* Sch. This is another uncommon species in the state. Available specimens were all collected during July and October in Boone, Iron, Lafayette, Newton, Reynolds and St. Louis counties.

40. *Chrysopa rufilabris* Burm. This species is only slightly more common than *interrupta*. Adults have been collected during July, August and September. Boone, Dunklin, Lafayette (EHF), Mississippi, Ste. Genevieve, Saline, Scott, Shannon and Stoddard counties.

Family Coniopterygidae

KEYS TO MISSOURI GENERA AND SPECIES

1. In fore wing the cross-vein from Cu runs into M at or beyond the only fork; in hind wing both radial sector and median vein forked, ... I. **Coniopteryx**
   In fore wing the cross-vein from Cu runs into M well before the fork (Fig. 14) 2
2.(1). Hind wings small and narrow, not over half the length of the front ones; hind wing with radial sector unforked ..... II. **Conwentzia**
   Hind wings only slightly smaller than front pair; hind wings with radial sector forked and median vein simple ..... III. **Malacomyza**

I. **Coniopteryx** Curtis

1. Body and wings dark; cross-vein between R and Sc about its length from cross-vein between R and Rs; length 2.6–2.9 mm ..... 41. **vicina**

II. **Conwentzia** Enderlein

1. Black or brown, wings paler, infused; all Cu and A veins connected by cross-veins (Fig. 14); length 3.6–4 mm ..... 42. **hageni** (Fig. 5)

III. **Malacomyza** Wesmael

1. Cross-veins in fore wing, except one between M and Cu, very faint, almost invisible; length 2.4 mm ..... 43. **westwoodi**

NOTES ON MISSOURI CONIOPTERYGIDAE

41. *Coniopteryx vicina* Hag. Our specimens have been swept from shrub and tree foliage in woods during May and August. Iron, Jefferson, Ste. Genevieve and Scott counties.

42. *Conwentzia hageni* Bks. A single specimen was taken in general sweeping in Ste. Genevieve County (EHF) on April 8.

43. *Malacomyza westwoodi* (Fitch). A lone specimen was found running nervously along a small branch of a wild cherry tree, *Prunus serotina* Erhr., in St. Louis County on May 6.

REFERENCES

This list includes not only those works which were useful in determining local material but also those containing Missouri records of the order. The latter are indicated by a dagger.

†**Banks, N.** 1892. A Synopsis, Catalogue, and Bibliography of the Neuropteroid Insects of Temperate North America. Trans. Am. Ent. Soc., 19: 328–373.

1903. A Revision of the Nearctic Chrysopidae. Trans. Am. Ent. Soc., 29: 137–162.

† 1905. A Revision of the Nearctic Hemerobiidae. Trans. Am. Ent. Soc., 32: 21–51.

1907. A Revision of the Nearctic Coniopterygidae. Proc. Ent. Soc. Wash., 8: 77–86.

1927. Revision of the Nearctic Myrmeleonidae. Bull. Mus. Comp. Zool. Harvard, 68: 1–84.

†**Carpenter, F. M.** 1940. Revision of the Nearctic Hemerobiidae, Berothidae, Sisyridae, Polystoechotidae and Dilaridae (Neuroptera). Proc. Am. Acad. Arts & Sci., 74: 193–280.

Comstock, J. H. 1936. An Introduction to Entomology. Ithaca, New York.

†**Hagen, H.** 1861. Synopsis of the Neuroptera of North America. With a list of South American Species. Smithsonian Misc. Coll., 4: 1–347.

†**Knetzger, A.** 1908. (Notes.) Ent. News, 19: 437.

†**Rau, P.** 1926. The Ecology of a Sheltered Clay Bank; a Study in Insect Sociology. Trans. Acad. Sci. St. Louis, 25: 157–277.

Rehn, J. W. H. 1938. Studies in North American Mantispidae. Trans. Am. Ent. Soc., 65: 237–266.
†**Riley, C. V.** 1870. Second Annual Report on the Noxious, Beneficial, and Other Insects of the State of Missouri. Jefferson City, Mo.
† 1875. Seventh Annual Report, etc.; same title. Jefferson City, Mo.
Smith, R. C. 1932. The Chrysopidae (Neuroptera) of Canada. Ann. Ent. Soc. Am., 25: 579–601.
1934. Notes on the Neuroptera and Mecoptera of Kansas, with Keys for the Identification of Species. Journ. Ks. Ent. Soc., 7: 120–145.
Weele, H. W. van der. 1908. Ascalaphiden Monograpisch Bearbeit. Coll. Zool. du Baron Edm. Longchamps, Fasc. 8, Bruxelles.

THE BUTTERFLIES OF WASHINGTON, by BEN V. LEIGHTON. University of Washington Publications in Biology, Vol. 9, No. 2, pp. 47–63, 1946. Price 45 cents.

Faunal lists can be extremely helpful to the taxonomist and they can be a source of worry. Whether they can be wholly one or the other is uncertain because they often include data from old collections which are not dependable and they are subject to the vagaries of identification.

This list inspires confidence since it is sponsored by the department of biology of the University of Washington. It is also carefully annotated, including a suggestion under *Poanes taxiles* that the insect may be incorrectly labelled. In the portion covering the Hesperioidea, with which the reviewer can claim critical familiarity, another identification seems extremely doubtful. *Hesperia viridis* Edwards is a southwestern species easily confused with *pahaska* Leussler which actually ranges from the southwest to the northern tier of states, hence it is almost certain that the record should be credited to the latter species. It is extremely doubtful too that true *Hesperia colorado* occurs in Washington. Regardless of these discrepancies the list should be helpful as a careful summary of Washington records of butterflies and skippers, since the references to specific material are complete and the identifications can therefore be checked.—A. W. L.

ARQUIVOS DE ZOOLOGIA DO ESTADO DE SAO PAULO, VOL. IV. 623. XLIII pages. Departamento de Zoologia da Secretaria da Agricultura, Indústria e Comércio, São Paulo, Brazil. 1946.

This large volume is made up of a series of articles on various groups of animals, including hydroids, birds and fishes as well as insects and other arthropods.

The articles on arthropods include the following titles: Excursão cientifica a Pôrto Cabral, margem paulista do Rio Paraná, by Lauro Travassos Filho. Estudios biológicos sobre alguns Lepidópteros do Brasil, Segunda nota suplementar a "Revisão das *Terias* americanas" and Revisão do gênero *Xanthocleis* by R. Ferreira d'Almeida, Técnicas gerais seguidas no estudo da ordem *Mantodea* Burmeister, 1838, and Sôbre a família *Acanthopidae* Burmeister, 1858, emend. (*Mantodea*) by Lauro Travassos Filho. Alguns aspectos bionômicos de *Leptopsylla segnis* (Schönh.) (*Suctoria*), by Lindolpho B. Guimãraes. Opiliões da colecão do Museu Nacional do Rio de Janeiro and Revisão dos Opilões do Departmento de Zoologia by B. M. Soares.

The reviewer has noted no descriptions of new species in the taxonomic papers but the extent of the material included should make them useful to specialists in the several groups.—A. W. L.

THE MORPHOLOGY AND MUSCULATURE OF THE LARVAL HEAD OF ANOPHELES QUADRIMACULATUS SAY[1]

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A study of the morphology and musculature of the fourth instar larval head of *Anopheles quadrimaculatus* Say (Diptera: Culicidae) was undertaken to determine the structure and functioning of its component parts. The morphology of the head of this species has apparently never been described. It is the purpose of this paper to present the anatomy of the head and to compare its structures with those found in other mosquito larvae.

Almost all of the numerous papers dealing with the Culicidae are purely taxonomic or bionomic in character. Meinert (1886), Raschke (1887), Nuttall and Shipley (1901), Johannsen (1903), Thompson (1905), Imms (1907, 1908), and Wesche (1910) describe in some detail the various head structures of mosquito larvae. Howard, Dyar, and Knab (1912) summarize the literature up to that time.

This work was undertaken to study the larval head of *Anopheles quadrimaculatus* and to compare it with the results given by Becker (1938) and Cook (1944b). Becker (1938) restricts his work to a study of the mouth brushes, their structure and function in feeding. Cook (1944b) devotes himself largely to the details of head structure of various mosquitoes (*Theobaldia incidens*, *Anopheles maculipennis*, *Lutzia halifaxi*, and *Armigeres malayi*) but fails to adequately describe the workings of the mouth brushes as used in feeding. Becker's interpretation of the mechanism of feeding seems, to the writer, the most tenable and is largely confirmed by the detailed study of the mouth brushes presented later in this paper.

Homologies between the structures present in *Anopheles* and those of other Dipterous larvae have been indicated insofar as this is possible. References to the plates will indicate the great complexity of the palatal and labial regions (figs. 5, 7, 8, 12, 16). The prementum of the labium has deviated far from the condition usually found in more generalized insects. The actual homologizing of its parts may have to be postponed until more information is obtained from examinations of this structure in other larvae of the Culicidae. The various head hairs, antennal, maxillary, and mandibular tufts of setae, and other similar characteristic outgrowths of the cuticula have been omitted from the illustrations.

MATERIALS AND METHODS

The fourth instar larvae were killed in hot water or in Dietrich's fluid, either of which had been heated to 60° C. The insects were

[1]The author wishes to express her sincere appreciation to Dr. Robert Matheson for suggesting and directing the work done on this problem.

fixed in Dietrich's solution and were stored in 50% alcohol. Actually little storage was necessary as living eggs were obtained from the Tennessee Valley Authority and the United States Department of Agriculture Experiment Station at Orlando, Florida. The larvae were reared in the laboratory, and thus a constant source of fresh material for study was always available.

The larval heads were dissected either in water or in glycerine, although the water medium was found to be preferable. A binocular dissecting microscope was employed and most of the work was done with a magnification of 108×. For detailed studies, a compound microscope was used with a magnification of 430×.

Complete serial sections of the head at various angles were also made. The sections were cut at 6μ and 12μ and were stained with Heidenhain's iron haematoxylin. Alcoholic eosin was employed as the counter-stain. Intensive studies of these sections were made to confirm the results obtained by the more gross dissections.

MORPHOLOGY OF THE HEAD

The head capsule is composed of the clypeus and the ocular lobes. The median clypeus is bounded posteriorly and laterally by the clypeofrontal suture, and anteriorly by the clypeolabral suture (figs. 1, 2). Anteriorly in the clypeofrontal suture and next to the bases of the antennae there is present a deep infolding of the cuticula to form a strong internal phragma (pp. figs. 6, 11), the paraclypeal phragma (Ferris, 1943). This structure gives rise to the anterior tentorial arm and the anterior articulation of the mandible. This would seem to be a further development of similar structures found in *Theobaldia* by Cook (1944b). In larvae of this genus, the phragma originates from a fold (the paraclypeal fold) in the cuticula, just lateral to the clypeofrontal suture. It is thus a part of the antennal segment since it bears the anterior tentorial pit and the anterior articulation of the mandible. In *Anopheles maculipennis*, the paraclypeal fold has "passed into the clypeofrontal suture" (Cook, 1944b). It is safe to surmise that the same development has occurred in the closely related species *A. quadrimaculatus*. The remainder of the antennal segment is not clearly defined from the rest of the cranium.

The eyes are situated laterally on the ocular lobes. The crescent-shaped, heavily pigmented bodies are the primordial ommatidia of the adult. The simple larval eye is located slightly posterior to the forming adult eye, and appears as a round blackened spot in the cuticula.

The ocular lobes comprise the lateral portions of the cranium (ol, fig. 2) and extend around the head ventrally to the premaxillary sutures (pms). The midventral portion of the cranium (fig. 12) is composed of the maxillary segment, although its limits are not clearly defined. The maxillary segment has expanded anteriorly and has developed into a more or less triangular plate, termed the maxillary plate, which overhangs the labium.

From the posterior margin of the head, the median suture extends forward along the mid-ventral line to the maxillary plate. The poserior tentorial pits (ptp, fig. 12) are located laterally in the head capsule to either side of the median suture (ms).

The Clypeus: The dorsal portion of the head is quite heavily sclerotized, and is made up of the clypeus and the ocular lobes. The clypeus is a large sclerite covering most of the dorsum of the head. It is bounded posteriorly and laterally by the clypeofrontal suture and anteriorly by the clypeolabral suture (cfs, cls, figs. 1, 2). On its inner face are found the origins of several muscles of importance.

The largest of these are the messorial muscles, (the muscles associated with the movement of the mouth brushes). The inner pair (im, figs. 1, 9) are located in a median and posterior position, while the external pair (em) are placed more anteriorly and laterally. Behind the internal messorial muscles are found the origins of the posterior pharyngeal muscles (ppm). On the central portion of the clypeus originate the median pharyngeal (mpm) and median palatal muscles (mpa). Near the clypeofrontal suture on either side are the lateral pharyngeal muscles (lpm). Anterior to these are the origins of the four pairs of cibarial muscles (cm) (see figs. 1, 9).

There has been some discussion as to whether the area which we have designated as the clypeus is actually the true clypeus or a combined clypeo-frons (Cook, 1944b). It has been variously described by the early morphologists. Meinert (1886) regards this area as the "scutum of the third metamere," Howard, Dyar, and Knab (1912) term it the front or epistoma, while later authors tend to call it the frons.

Snodgrass (1928, 1935) has defined the clypeus as that area of the head on which the dorsal dilator muscles of the cibarium originate. In accordance with this definition, the median dorsal sclerite of the larval head with which we are dealing, can be none other than the true clypeus, as the origins of the cibarial, messorial, and median palatal muscles are found thereon. Cook (1944b) points out that "the clypeofrontal suture is clearly identified by its termination anterior to and mesad of both the anterior mandibular articulation and the anterior tentorial pits."

The Paraclypeal Phragma and Associated Structures: Anterior and contiguous to the antennal bases, there is present a deep infolding of the head wall along the clypeofrontal suture. This structure is the paraclypeal phragma. It is continuous with the outer ventral wall of the cranium which extends anteriorly to articulate with the messorial sclerites of the mouth brushes (mes, figs. 9, 11). From its inner edge on either side of the head arise the slender anterior tentorial arms. The anterior tentorial arms are elongate and rather weak in this species. They extend backward in the head to meet the much shorter posterior tentorial arms, which are invaginated from pits on either side of the ventral median suture. The anterior arm bears, somewhat posteriorly along its length, the origin of the antennal muscle (am, figs. 6, 11). This muscle is inserted at the inner and ventral edge of the scape of the antenna. It is the only antennal muscle present and functions as a levator.

Also arising from the inner margin of the paraclypeal fold is another phragma (pab, fig. 6), termed the postantennal buttress (Cook, 1944b). It extends from the paraclypeal phragma, behind the antennal foramen to the cranial wall. Its point of invagination from the head capsule is indicated exteriorly by a small line (pab, figs. 1, 2). It serves along

with the paraclypeal phragma and the tentorium to support and strengthen the cranium.

From the inner edge of the origin of the anterior tentorial arm arises a rod-like sclerite known as the cibarial bar (Cook, 1944b). The cibarial bar (cb, fig. 11) extends ventrally and is fused with the heavily sclerotized rim of the prementum of the labium. In this position, it forms a strong margin around the ventral posterior border of the preoral cavity. Just beyond its point of origin, the cibarial bar bears the anterior articulation of the mandible (aam, figs. 6, 11).

The Labrum: The labrum has also been given a variety of names by other workers. The narrow sclerotized strip of cuticula just anterior to the clypeofrontal suture is usually referred to as the clypeus in taxonomic studies. The more or less triangular membranous area just anterior to it has been termed the labrum. As Cook (1944a, 1944b) has pointed out in his recent papers, this narrow area cannot be the clypeus, since there are no muscles originating on its inner face. The cibarial muscles almost always diagnostic of the clypeus (Snodgrass, 1928, 1935) have their origins posteriorly and on the large dorsal sclerite which was designated above to be the true morphological clypeus. The narrow sclerite is believed by Cook (1944b) to be "all that is left of the dorsal sclerotization of the labrum."

The most anterior membranous part of the head may probably contain some portion of the dorsal labral elements. This membranous area (mma, figs. 1, 2, 12) bears laterally the mouth brushes and anteriorly gives rise to a rounded projection on which are borne numerous strong bristles. This projection overhangs the structures found on the palatum, or underside of the labrum. These will be described in detail below.

The Palatum and Mouth Brushes: The structure of the mouth brushes and of the various sclerites found on the under side of the labrum have been studied and described by several workers. Meinert (1886), Raschke (1887), Nuttall and Shipley (1901), Thompson (1905), and Imms (1908) have described these structures in some detail and have given accounts of their probable function.

The actual structure of the palatum and mouth brush mechanism has been worked out in recent years by Becker (1938) and by Cook (1944b). Both authors dealt with ***Anopheles maculipennis***. The species here described is ***Anopheles quadrimaculatus***, but we have found that *A. quadrimaculatus* is practically identical with *A. maculipennis* as described by Becker (1938).

The lateral areas of the membranous portion of the labrum bear the mouth brushes and anteriorly the sclerotized median lobe which overhangs the palatum. Beneath, on the ventral surface of the palatum and separated from the base of the brushes by a narrow membranous fold, are a pair of flat sclerotized plates termed the lateral palatal plates by Cook (1944b) or the subflabellar sclerites of Becker (1938) (lpp, figs. 5, 7, 12). These are articulated posteriorly with the messores (mes). Anteriorly there is a membranous break between the lateral palatal plates and the messores. Overhanging this connecting membrane is a series of very small spines (figs. 7, 12).

The messores themselves (longitudinal levers of Becker, 1938) are a pair of sinuous, somewhat twisted plates which are connected anteriorly with the base of the brushes. Upon an arm-like projection in the anterior internal portion of each messor is attached the apodeme of the internal messorial muscle (aim, fig. 5).

To the median side of the articulation of the messores with the brushes (or flabellae) is attached an apparatus called the transverse girdle (tg) by Becker (1938) which connects the anterior ends of the messores just beneath the median lobe (ml) of the labrum (figs. 5, 7).

In the mid-ventral portion of the palatum, between the messores and beneath the transverse girdle, is a slight membranous protuberance. It is supported by a V-shaped sclerotized bar (ppb, fig. 5), termed the posterior palatal bar (Cook, 1944b), or endoskeletal arch (Becker, 1938). From the posterior palatal bar, just lateral of the mid-ventral line, arise two somewhat triangular shaped structures (ta). From these originate two groups of bristles which overhang the entrance to the cibarial cavity (figs. 7, 12). At the point of the V, formed by the posterior palatal bar, is inserted the apodeme of the two slender median palatal muscles (mpa, figs. 5, 9). These muscles originate on the inner central portion of the clypeus (fig. 1). The lateral ends of the posterior palatal bar are attached to the median margin of the messores. The external pair of messorial muscles are inserted upon apodemes which arise from the ends of the posterior palatal bar close to the point where the latter is articulated to the messores (aem, fig. 5). Cook (1944b), in his study of *Anopheles maculipennis*, states that both pairs of messorial muscles are inserted on the messores. This inaccuracy must have arisen from an error in observation as the external messorial muscles are definitely inserted on the lateral tips of the posterior palatal bar. This is further corroborated by Becker (1938), who worked with *Anopheles maculipennis*, and thus the conflicting statements as to the location of these muscles cannot be due to a species difference.

The posterior tapering tips of the messores are articulated to the ventro-lateral cranial wall, which is the anterior extension of the paraclypeal phragma.

There have been various theories proposed as to the actual working of the mouth brush mechanism. Raschke (1887) believed that the internal messorial muscles functioned as extensors and the external pair as flexors of the brushes. Nuttall and Shipley (1901) state that the brushes are capable of independent action. Howard, Dyar, and Knab (1912) say that by retractor muscle action and subsequent relaxation, the "side pieces" are jerked forward and backward. More agreement is found in the papers of Thompson (1905) and Imms (1908). Both maintain that all muscles contract simultaneously to depress the brushes. Upon the relaxation of the messorial muscles, the normal extended attitude of the brushes is regained by virtue of the elasticity of the framework.

Becker (1938) has presented a somewhat different theory of operation which he describes in detail. He states that by the contraction of the internal messorial muscles, the anterior ends of the messores (near which the latter muscles are inserted) are brought together along the median line. The inverse movement of the posterior portion of the

messor is automatic, and is brought about "by a deformation of the lateral margin of the clypeus," at which point the posterior end of the messor rests. The transverse girdle, which connects the anterior ends of the messores, helps in bringing their ends together by folding in two and thus "contributes . . . to the formation of the median longitudinal fold, on the lateral slopes of which both flabellae fall." Becker (1938) also says that the transverse girdle directs the motion of the median lobe, which naturally follows, since it is attached anteriorly to this structure. At the posterior portion of the palatum (Becker's epipharynx) is located the median protuberance which forms the permanent part of the median fold on which the brushes fall. The contraction of the paired external messorial muscles inserted on the lateral tips of the posterior palatal bar (aem, fig. 5) assist in the action of the inner messorial muscles (aim, fig. 5). Their contraction is also able to change the position of the posterior palatal bar. According to Becker (1938), the median palatal muscle (mpa, figs. 5, 7, 9) is the antagonist of the external messorial muscle.

It is most probable that Becker's statement of the labral mechanism is correct; this agrees with the writer's interpretation. The external messorial muscles, then, assist the internal messorial muscles by pulling the posterior palatal bar to a more anterior position. Such a position would deepen the longitudinal palatal fold and cause the mouth brushes to be depressed to an even greater extent. The action of the median palatal muscle would return the posterior palatal bar to its original location. By this pull, along with the elasticity of the cuticula, the longitudinal fold would straighten out and cause the brushes to return to their normal position.

The messores themselves can be homologized with the so-called "lateral arms" of Johannsen (1903) found in the larvae of the Chironomidae. In the latter family the messores form a pair of sclerotized arm-like processes which extend posteriorly toward the mouth (Cook, 1944c). They are invaginated in part beneath the palatal surface. The musculature of these structures is the same as that found in larval Culicidae according to Cook (1944c), except that the apodemes are poorly developed. The origins of the four muscles belonging to the messores are located "on the posterior half of the clypeus with the median pair originating slightly anterior to the origins of the median pharyngeal muscles" (Cook, 1944c). This author also says that the messores of *Chironomus* articulate with a transverse sclerite which may be the homologue of the posterior palatal bar of the Culicidae.

The Mandibles: The mandibles are, in general, much like those of the typical mandibulate insect. They have deviated somewhat, however, from the generalized type. From the mandible is developed an elongate sclerotized arm which extends ventrally to the cranial wall. The posterior articulation is located at this point. This arm-like projection (ma, figs. 3, 4) also extends around the base of the maxillary palpus (mxp) and thus aids in its support. Such a mandibular arm has also been described by Cook (1944b) in his study of the larva of *Anopheles maculipennis*.

The abductor muscles (mab, figs. 2, 3, 11) are inserted upon an apodeme located on the posterior rim of the mandible, close to the

origin of the arm-like sclerite. The abductor muscle is composed of two major bundles. One originates latero-dorsally on the ocular lobe near the primordial adult eye crescent. The other is divided into two smaller bundles both of which are located more ventrally.

The adductor muscle (mad, figs. 2, 11) is inserted on a large apodeme and is composed of four main groups which may be secondarily divided. These originate laterally and ventrally on the ocular lobes, near the posterior margin of the cranium.

The Maxillae: The maxilla is trapezoidal in shape and is composed of the palpus and the stipes, which may include the galea and the lacinia (Cook, 1944b). It is attached to the wall of the head along its entire ventral length (mx, fig. 12). At its inner margin a strong sclerotized arm arises (y, figs. 3, 4). This rod extends to a position lateral to the dorsal edge of the labial prementum. At this point the arm of the maxilla articulates with another sclerotized rod (z) which extends upward from a point just lateral to the attachment of the prementum with the maxillary segment. At the dorsal articulatory point of these two structures, a small apodeme from the maxillary arm extends posteriorly (amxm, figs. 3, 4). Upon this apodeme is inserted the maxillary muscle of Cook (1944b). The maxillary muscle (mxm, figs. 4, 11, 12) originates on the ventral cranial wall just below and mesad to the posterior tentorial pits. According to Cook (1944b), the apodeme acts as a lever to increase the strength of the maxillary muscle.

The other muscle of the maxilla, described as the cranial flexor of the stipes by Cook (1944b), originates on the latero-ventral portion of the ocular lobe (cs, figs. 2, 4), between the two diverging bundles of the mandibular abductor muscle (mab) and posterior to the larval eye (le.) It is inserted on the inner dorsal face of the maxilla.

The palpus is attached to the maxilla on the outer margin of the latter. It is also supported by the mandibular arm (ma, figs. 3, 4) which was described above. There are no muscles inserted on the palpus and its movement is dependent upon that of the maxilla and, to some extent, that of the mandible.

The Labium: The labium is composed of several parts whose homologies are extremely confusing. Ventrally, the maxillary plate (mxpl), an extension of the maxillary segment (Cook, 1944b) overhangs the labial structures (figs. 2, 7, 12). The maxillary plate has received several names. Meinert (1886) calls it the "scutum of the second metamere," while Raschke (1887) terms it the mentum or "*Kinn*." Imms (1907) defines this structure as the submentum, while Howard, Dyar, and Knab (1912) call both the maxillary plate and what is probably the true mentum "excrescences of the mentum."

The labium is made up of three, or possibly four parts. Just within the maxillary plate (mxpl) is a toothed projection which, in this species, bears one central spine and six lateral spines on either side. This structure (smt, fig. 14) has been called the aulaeum by Cook (1944b), and is considered to be the submentum by most workers. Dorsal to the submentum is a heavily sclerotized, toothed plate, known as the mentum. In *Anopheles quadrimaculatus*, the mentum (mt, fig. 10) bears four lateral spines on each side of a larger central tooth. According to Cook (1944b), the submentum or aulaeum is present only in the Culi-

cidae while the mentum is present in many other Dipterous larvae. He also states that when reduction of parts takes place in the labium, the submentum is the more stable, while the mentum is lost. He concludes that it is possible that the aulaeum is merely a secondary development of a fold between the maxillary plate and what, in this event, would be the true submentum (described above as the mentum).

Dorsal to the mentum and resting in a position perpendicular to the longitudinal axis of the body is the heavily sclerotized prementum (pmt, figs. 8, 16). Just ventral to the prementum is a series of small toothed structures (figs. 8, 15, 16). These consist of a heart-shaped flap (fig. 15) located above the mentum and arising from the base of the prementum. The flap is bounded ventrally by a series of jagged, transparent, sclerotized teeth (fig. 15). Above the heart-shaped flap arises a slender leaflike structure toothed on its distal end (fig. 15).

Just dorsal to the latter is the prementum itself (pmt, figs. 8, 16). Along its median line arise a series of heavy teeth. Placed laterally to these are many smaller tooth-like spines. Ventrally and just above the leaflike structure mentioned above, the central portion of the prementum swings downward in a median projection. On either side of this projection is a roughly circular, more membranous area. This area bears four blunt tapering spines on each side of the median projection (figs. 8, 15).

The entire prementum is square in shape and is bounded by heavily sclerotized bars. On the median posterior aspect of the bars supporting the prementum laterally, are inserted the labial adductor muscles. These muscles (lm, figs. 11, 16) originate on the cranium just beneath the maxillary muscles.

The orifice of the common salivary duct (sd, figs. 8, 11, 16) is located on the anterior and most dorsal aspect of the prementum which has been termed the hypopharynx by some authors (Johannsen, 1903; Imms, 1907).

The Pharynx: The pharynx of the mosquito larva is a very peculiar pouch-like structure. Its position within the head (figs. 7, 9) is somewhat oblique to the longitudinal axis of the body. It is an oval structure whose curving lateral margins are sclerotized both dorsally and ventrally, while the middle regions are membranous. The arching borders of the pharynx were called the "crests" of the pharynx by Thompson (1905), and "the elliptical flat ring" by Johannsen (1903). The lateral sclerotization of the external pharyngeal wall (lp, fig. 13) is formed by three concentric rings or bars (ra, rb, rc) in the cuticula which extend dorsally. The dorsal terminations of these bars on either side are connected by the median membranous portion (dp) of the pharynx (figs. 9, 13). Within the pharyngeal cavity itself, two rows of bristles extend into the lumen. These bristles (f, fig. 17) originate on the second and inner of the concentric bars (rb, rc) mentioned above.

Laterally the sclerotized edges of the pharynx are articulated to the cibarial bar (cb) by two curving, somewhat U-shaped structures (u, fig. 13). The dorsal membranous wall of the pharynx is continuous with the dorsal wall of the cibarial cavity (figs. 7, 9). The ventral wall is attached to the prementum (pmt) just dorsal to the opening of the salivary duct (sd, fig. 7).

The internal fimbriae, or setae, found in the pharyngeal cavity were first described by Raschke (1887) who thought they represented a straining apparatus. Johannsen (1903) mentions these bristles and considers that they are a sieve-like mechanism. They are also described by Imms (1907). Cook (1944b) compares the pharyngeal mechanism of several larvae, and figures the bristles in *Theobaldia incidens*, *Armigeres malayi*, and *Anopheles maculipennis*.

The musculature of the pharynx of *Anopheles quadrimaculatus* closely corresponds to Cook's (1944b) findings in other mosquito larvae. Originating on the anterolateral margins of the clypeus are the four pairs of cibarial muscles. These muscles (cm, figs. 1, 9) are inserted fanwise on the dorsal anterior portion of the pharynx, and on the dorsal posterior margin of the roof of the cibarial cavity. The cibarial muscles function to dilate the preoral cavity and the mouth.

The four intrinsic pharyngeal muscles (ip, figs. 9, 13) connect the curving lateral sclerotizations of the pharynx. The two pairs of lateral pharyngeal muscles (lpm, figs. 9, 13) originate on the clypeus near the clypeofrontal suture and are inserted on the lateral margins of the pharynx. The two median pharyngeal muscles (mpm, figs. 9, 13) are inserted on the mid-dorsal posterior portion of the pharynx and extend upward to the clypeus.

There are two pairs of posterior pharyngeal muscles (ppm, figs. 7, 9, 13). The first pair originate on the posterior lateral area of the clypeus. These cross over each other to insert at the margin of the pharynx on the opposite side to their respective points of origin. The second pair are inserted on the dorsal margin of the pharynx and extend to the median posterior wall of the clypeus. These muscles were described in full, under different names by Imms (1907) in his paper on *Anopheles maculipennis*.

The action of the intrinsic muscles, aided by the first pair of posterior pharyngeal muscles, causes the pharynx to be folded together and the lateral sclerotizations to approximate. By this contraction, the food is forced backwards into the oesophagus.

The oesophagus (oe, fig. 7) continues posteriorly from the ventral side of the median pharyngeal area. The ventral pharyngeal muscle holds the oesophagus firmly in place. This muscle (vp, fig. 7) originates on the ventral cranial wall and is inserted on the anterior oesophagus beneath the circumosoephageal commissure.

The details of the central nervous system have not been included in the figures, although the supraoesophageal (b) and frontal (fg) ganglia are indicated (fig. 9).

CONCLUSIONS

A detailed study of the morphology of the fourth stage larval head of *Anopheles quadrimaculatus* has been presented. The morphology of this larval head closely tallies with that of *Anopheles maculipennis*. There appear to be only a few points of difference between the two species.

Anopheles quadrimaculatus differs from the latter species in the following ways:

The median pharyngeal muscle, not described by Cook (1944b), is present and well developed.

There are present four pairs of cibarial muscles inserted on the dorsal aspect of the pharynx and preoral cavity in the mosquito larva here discussed, whereas Cook (1944b) figures only three pairs in his illustrations of *Anopheles maculipennis*.

The intrinsic pharyngeal muscles of the larva of *Anopheles quadrimaculatus* are differently spaced. The most posterior pair of intrinsic muscles are rather widely separated, while the anterior pair are set very close together (fig. 13). The opposite situation is apparently true in the case of *Anopheles maculipennis*, as here the posterior pair are contiguous and the anterior pair are more widely spaced.

The adductor and abductor mandibular muscles of *Anopheles maculipennis*, as figured by Cook (1944b), are divided into a different arrangement of bundles. Both sets are shown attached to the dorsolateral margin of the head. In the larva of *Anopheles quadrimaculatus*, the abductor muscle is clearly divided into two large diverging bundles, one of which originates ventrally. The adductor muscle of this species is separated into four bundles, the largest of which also originates more ventrally on the cranium.

Finally, Cook (1944b) considers that both pairs of messorial muscles are inserted on the messores. Only the inner muscles are attached to the messores in larvae of *Anopheles quadrimaculatus*. The outer pair are definitely inserted on the lateral tips of the posterior palatal bar. It is here believed that this discrepancy between the two species is due to an error in observation on Cook's part.

Other points of general morphological interest concerning the larva here considered are listed in the following summary.

The labium is greatly reduced and is made up of three peculiar and highly specialized parts: the submentum, the mentum, and the prementum. The homologies of these structures are not clear.

The orifice of the salivary duct is located on the dorsal margin of the prementum.

The pharynx is an unusual pouch-like organ, supported laterally by three arching, sclerotized rings which are attached to the cibarial bars by U-shaped sclerites. The two inner sclerotized rings each bear internally a row of stiff setae which extend into the pharyngeal cavity and function as a straining mechanism.

It is believed that a convincing theory which accounts for the movement of the labral brushes has been presented and this agrees with the work of Becker (1938).

The paraclypeal phragma is invaginated along the anterior portion of the clypeofrontal suture. From it arises the anterior tentorial arm.

The cibarial bar is strongly developed in this species and extends from the inner edge of the anterior tentorial arm to the prementum, thus bounding the preoral cavity ventrally. The cibarial bar also carries the anterior articulation of the mandible.

The mandible has developed an elongate sclerotized arm which articulates with the ventral cranial wall. This arm also passes around the base of the maxillary palpus and supports the latter structure.

The maxilla is greatly reduced and is composed of the stipes and the palpus. All other maxillary components appear to have been lost.

Up to the present time, papers concerned with the morphology of larval Culicidae have dealt with only a few selected forms. It is probable that a more extended study covering a large number of different species will bring more direct evidence to bear on the homologies of some structures of the head which are now in question.

LIST OF ABBREVIATIONS

a—antenna.
aam—anterior articulation of the mandible.
aem—apodeme of the external messorial muscle.
af—antennal foramen.
aim—apodeme of the internal messorial muscle.
am—antennal muscle.
amab—apodeme of mandibular abductor muscle.
amxm—apodeme of maxillary muscle.
ata—anterior tentorial arm.

b—brain, or supraoesophageal ganglion.
blb—base of labral brush.

cb—cibarial bar.
cfs—clypeofrontal suture.
cl—clypeus.
cls—clypeolabral suture.
cm—cibarial muscles.
cs—cranial flexor muscle of the stipes.

dp—dorsal wall of the pharynx.

em—external messorial muscle.

f—fimbriae extending into the pharyngeal cavity.
fg—frontal ganglion.

ie—primordia of imaginal eye.
im—internal messorial muscle.
ip—intrinsic muscles of the pharynx.

lb—lateral mouth brush.
le—larval eye.
lm—labial adductor muscle.
lp—lateral sclerotization of the pharynx.
lpm—lateral pharyngeal muscle.
lpp—lateral palatal plate.

m—mandible.
ma—mandibular arm.
mab—mandibular abductor muscle.
mad—mandibular adductor muscle.
mb—median bristles.
mes—messor.
ml—median lobe.
mma—median membranous area of the labrum.
mpa—median palatal muscle.
mpm—median pharyngeal muscle.
ms—median ventral suture.
mt—mentum.
mx—maxilla.
mxm—maxillary muscle.
mxp—maxillary palpus.
mxpl—maxillary plate.

oe—oesophagus.
ol—ocular lobe.

p—palatum.
pab—postantennal buttress.
pam—posterior articulation of the mandible.
pms—premaxillary suture.
pmt—prementum.
pp—paraclypeal phragma.
ppb—posterior palatal bar.
ppm—posterior pharyngeal muscle.
pta—posterior tentorial arm.
ptp—posterior tentorial pit.

ra—external sclerotized pharyngeal ring.
rb—median sclerotized pharyngeal ring.
rc—inner sclerotized pharyngeal ring.

sd—salivary duct.
sl—sclerotized portion of the labrum.
smt—submentum.
so—salivary duct orifice.

ta—triangular sclerite of posterior palatal bar.
tg—transverse girdle.

u—U-shaped sclerite of the pharynx.

va—ventral anterior wall of the head.
vp—ventral pharyngeal muscle.

y—sclerotized arm of the maxilla.

z—sclerotized rod lateral to the prementum.

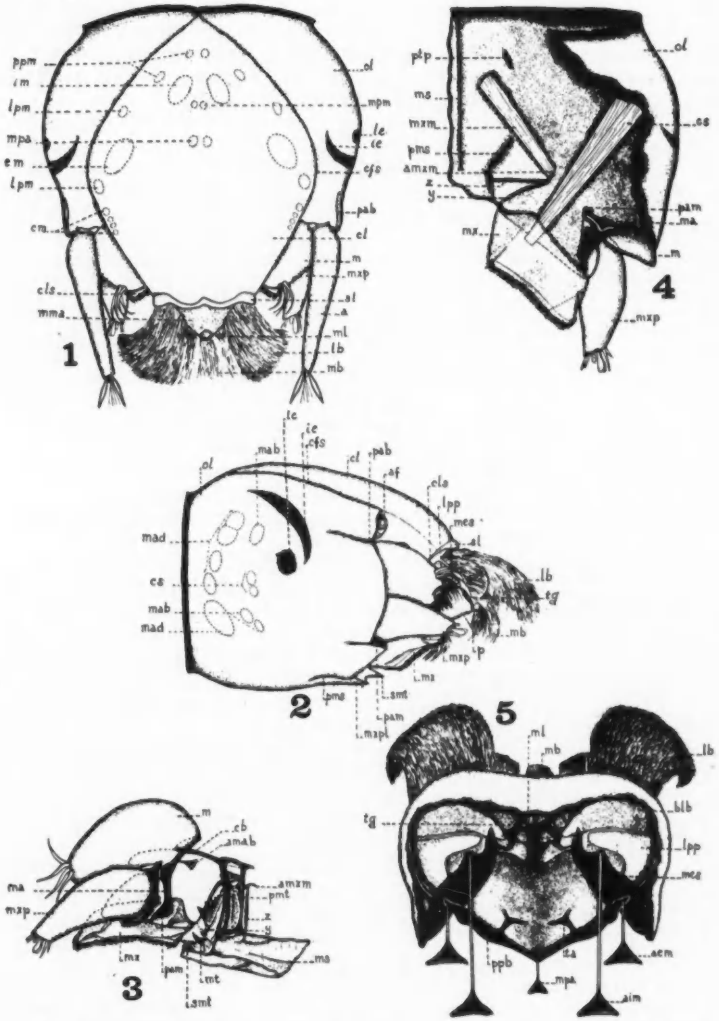

FIG. 1. Dorsal external view of the head. The dotted circles indicate the origins of muscles on the clypeus. FIG. 2. Lateral external view of the head. The dotted circles indicate the origins of muscles on the ocular lobe. Fig. 3. Lateral oblique view of the mandible, maxilla, and labium illustrating the apodeme of the maxillary muscle and the mandibular arm supporting the maxillary palpus. FIG. 4. Dorsal internal view of the left maxilla with its palpus showing the origin and insertion of the cranial flexor muscle of the stipes, and the attachment of the mandibular arm to the ventral cranial wall. FIG. 5. Internal view looking anteriorly into the labrum and palatum to illustrate the transverse girdle, lateral palatal plates, messores, and posterior palatal bar.

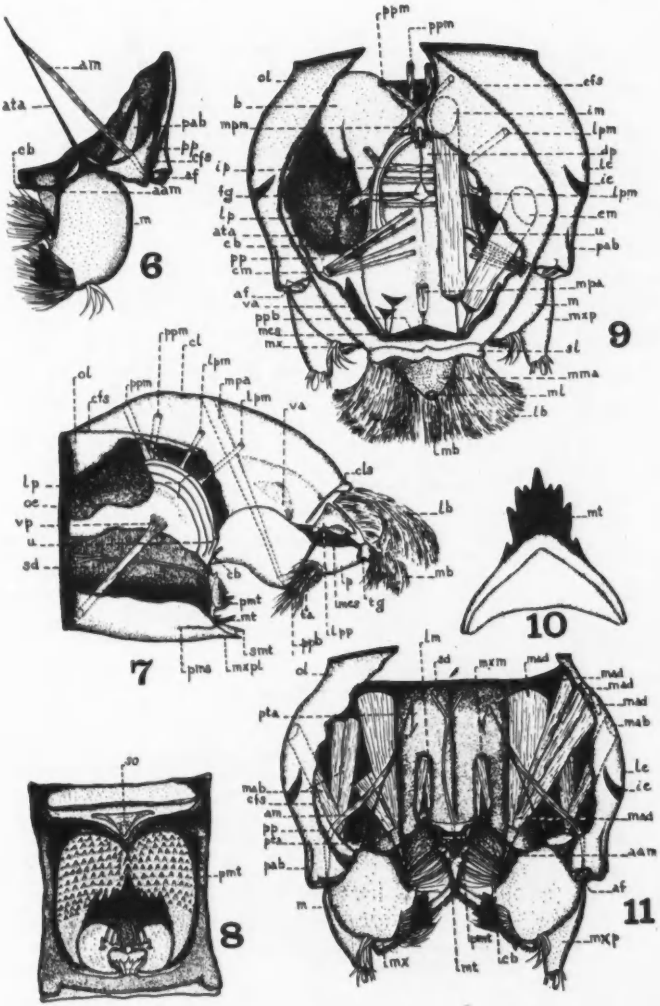

FIG. 6. Dorsal view of the left mandible with a section of the head capsule removed to show the paraclypeal phragma and the post-antennal buttress. FIG. 7. Lateral view of the head and palatum with the mandibles, maxillae, and part of the ocular lobe removed to show the pharynx and its muscles, the salivary duct, and the labium. FIG. 8. Frontal aspect of the prementum of the labium. FIG. 9. Dorsal aspect of the head partially dissected to show the position of the nervous system, the pharynx with its muscles, and related structures. FIG. 10. Ventral view of the mentum of the labium. FIG. 11. Dorsal aspect of the head. The clypeus, labrum, palatum, and pharynx have been removed to show the tentorium, cibarial bar, and muscles of the mouthparts.

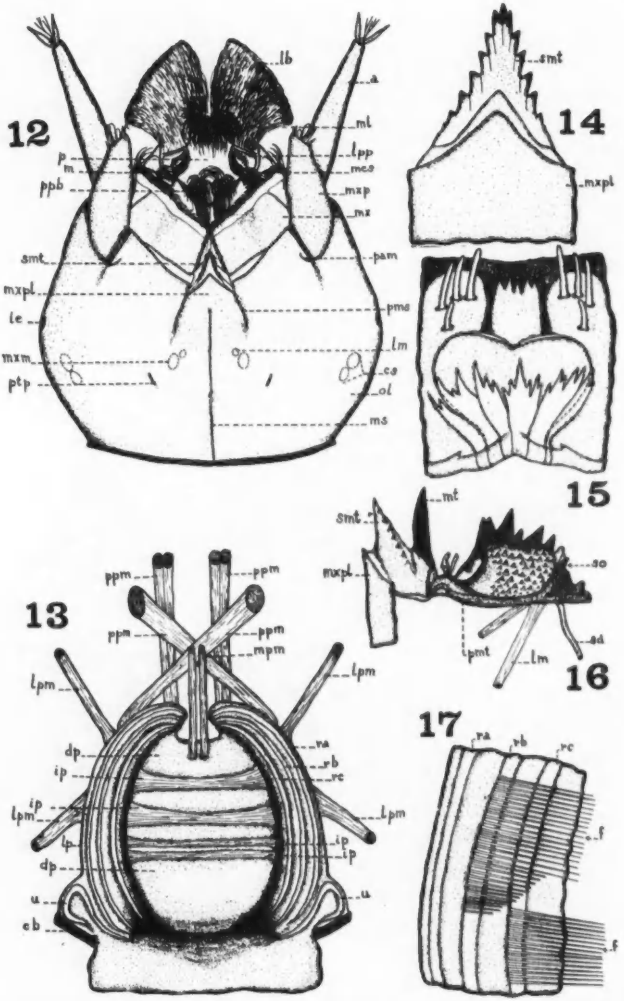

FIG. 12. Ventral external view of the head. The dotted circles indicate the origins of muscles on the head capsule. Fig. 13. Dorsal detailed view of the pharynx and its muscles. FIG. 14. Ventral view of the maxillary plate and the submentum of the labium. FIG. 15. Detailed view of the heart-shaped flap and associated structures of the prementum. FIG. 16. Lateral view of the maxillary plate, submentum, mentum, and prementum of the labium. FIG. 17. Internal view of a section of the lateral sclerotization of the pharynx illustrating the two rows of fimbriae extending into the pharyngeal cavity.

BIBLIOGRAPHY

Becker, E. 1938. The mouth apparatus of the Anopheles larva and its movements in feeding upon organisms of the surface film water. Zoologitsheskij Journal, Vol. XVII, Fascicle 3, pages 427–440.

Cook, E. F. 1944a. The morphology and musculature of the labrum and clypeus of insects. Microentomology, Vol. 9, Part 1, pages 1–35.

1944b. The morphology of the larval heads of certain Culicidae (Diptera). Microentomology, Vol. 9, Part 2, pages 38–68.

1944c. On the morphology of the larval head of Chironomus (Diptera: Chironomidae). Microentomology, Vol. 9, Part 2, pages 69–77.

Ferris, G. F. 1943. The basic materials of the insect cranium. Microentomology, Vol. 8, Part 1, pages 8–24.

Howard, L. O., H. G. Dyar, and **F. Knab.** 1912. The mosquitoes of North and Central America and the West Indies. Carnegie Institution of Washington, Publication Number 159.

Imms, A. D. 1907. On the larval and pupal stages of *Anopheles maculipennis* Meigen. The Journal of Hygiene, Vol. 7, No. 2, pages 291–318.

1908. On the larval and pupal stages of *Anopheles maculipennis* Meigen. Parasitology, Vol. I, No. 9, pages 103–133.

Johannsen, O. A. 1903. Aquatic nematocerous diptera. New York State Museum Bulletin 68, pages 328–448.

Meinert, F. 1886. De eucephale myggelarver. Det Kongelige Danske Videnskabernes Selskabs Skrifter. Sjette Raekke. Naturvidenskabelig og Mathematisk Afdeling. Tredje Bind, pages 372–493.

Nuttall, G. H. F., and **A. E. Shipley.** 1901. The structure and biology of Anopheles. The egg and larva. The Journal of Hygiene, Vol. I, No. 1, pages 45–77.

Raschke, E. W. 1887. Die larve von *Culex nemorosus*. Ein betrag zur kentniss der insecten anatomie und histologie. Archiv für Naturgeschichte, Vol. 53, pages 133–163.

Snodgrass, R. E. 1928. The morphology and evolution of the insect head and its appendages. Smithsonian Miscellaneous Collections, Vol. 81, No. 3.

1935. Principles of Insect Morphology. McGraw-Hill Book Company, New York.

Thompson, M. T. 1905. The alimentary canal of the mosquito. Proceedings of the Boston Society of Natural History, Vol. 32, pages 145–203.

Wesche, W. 1910. On the larval and pupal stages of West African Culicidae. Bulletin of Entomological Research, Vol. I, Part 1, pages 7–50.

THE SIGNIFICANCE OF THE "EDITORIAL NOTES" IN THE REPRINTS OF THE EARLIER OPINIONS ON ZOOLOGICAL NOMENCLATURE

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Opinions of the International Commission on Zoological Nomenclature, beginning with Number 1, are being reprinted with "Editorial Notes" by Secretary Hemming. Certain of these notes are factual and historical in nature; others are interpretations, and as such they may be open to difference of opinion. For example—

(1) Opinion 1 (reprint), pp. 78–79.—The second of two names in the usual scientific name is to be called the "trivial name" and not the "specific name." The Commission's own use of the expression "specific name" in the summary of Opinion 1 is characterized as "loose." Yet the expression is used in that same "loose" sense in Articles 11 to 18 inclusive, 23, 25, and 32 of the Code itself, and in summaries of Opinions 1, 12, 13, 64, 70, 97, 128, and 134, as well as in numerous places in the discussions of the Opinions. Was the Commission then consistently "loose," or is that really the way it intended the expression "specific name" to be used?

(2) Opinion 6 (reprint), p. 131, footnote 9.—The Secretary's interpretation appears to be that a verbal statement of type designation is necessary for a monotypic genus to fulfill the requirements of Article 25 as amended in 1927 (requiring a "definite and unambiguous designation of the type species"). Yet in the view of Stiles and Stejneger, and of Dautzenberg (paragraphs 7 and 8, p. 131), "If a genus is monotypic, this is *ipso facto* designation of the most definite kind." And certainly unambiguous! Is there any reason to believe that a genus published with only one included species (monotypic), although this is not stated to be the type, is not valid under Article 25, even as amended? Was not the amendment intended to supplant only section II (on subsequent designation) of Article 30, after December 31, 1930?

(3) Opinion 6 (reprint), Editorial Note 3 (italics are mine).—The Secretary maintains that "The wording employed in Opinion 6 is ***absolutely unambiguous*** and leaves no loophole for misunderstanding as to the meaning or scope of the Commission's decision." He further states that the account of the discussion, in paragraph 2 of the Opinion, "makes it ***absolutely clear*** that the question then put to, and answered by, the members of the Commission was the ***strictly limited*** question then laid before the meeting in the form of a diagram."

It is true that the title of the Opinion mentions a genus with *two* species, as does the summary. Paragraph 2, however, states that "the position of the Commission upon cases of this kind was asked, and the reply was made by all members of the Commission who were present

that *cases which were as clear* as the one given in the diagram should be construed under Article 30 (g), namely, that the type of the original genus was fixed when, through a division of its species, it was definitely made into a monotypic genus."

It seems reasonable to infer that the consensus of the Commission was that any such *clear-cut* case would be treated in like manner, even though it involved more than two species. Would it not have been an equally *clear* case had the genus A____ contained *three* species, A____ b____, A____ c____ and A____ d____, with a later author removing A____ c____ and A____ d____ to a new genus or to two new genera, leaving genus A____ with one species, b____, and hence monotypic?

Whether the individual reader agrees or disagrees with the views expressed in the above examples is immaterial at this time. The essential point is that these footnotes and editorial notes have the appearance of formality and may be accepted by some at face value as a part of the respective Opinions. However, it should be clearly understood (and this ought to be definitely stated in any such notes that accompany reissued Opinions) that these comments are not necessarily the *Opinion* of the Commission as a whole, have not been voted on or approved by the Commission, and cannot and do not share the force of the original Opinion. In any problems where more than one interpretation is possible, the case cannot legitimately be decided by these notes alone.

MAN THE ANIMAL, by RAYMOND PEARL. 128 pages. 1946. The Principia Press, Bloomington, Indiana. Price $2.50.

In the reviewer's opinion Doctor Pearl was the most comprehensive and penetrating analyst of our own species that the biological profession has produced in the twentieth century. That opinion is a confession of close agreement with his conclusions and also a forecast of enthusiasm for his small posthumous volume.

Man the Animal includes the five Patten Foundation Lectures delivered at Indiana University in October, 1938. According to the foreword it was his intention to expand the lectures before publication but when he died on November 17, 1940, the work had not been done. His manuscript was prepared by Mrs. Pearl with the help of some of his friends and is now presented in book form. Even though it is not as he would have completed it, the book is a monument to the fine intelligence of the writer in applying to mankind the biological knowledge which should long ago have given us better understanding of ourselves and a sounder solution of human problems than other approaches have provided.

Dr. Pearl's first two lectures deal with man as the unique mammal. The first considers matters that are more or less common knowledge among biologists. The relation of man to the anthropoid apes and the nature of his primate ancestry are treated briefly and with them the essential distinctions of upright posture, large brain, articulate speech and longer life span, of which the last is not discussed in detail. The first three are fundamentally related in providing man with essential tools, his hands, with the ability to use them effectively, and with the means of communicating and perpetuating his discoveries. A discussion of his far-reaching attainments in supplementing his biological adaptations with tools in the broad sense of the word concludes the lecture. "All useful machines," the author says, "are additions to the biological equipment of man as an animal. Some are additions to his motor powers; others to his sensory. But their fundamental meaning is always biological. Except as a part of man's biological equipment they have no significance."

In the second lecture the role of this peculiar ability in providing man with the elaborate environment of civilization is discussed in some detail, with a final blunt comment on the human claim of rational conduct: "But really only a small fraction of his behavior is rational. The rest is just mammalian, or of still lower evolutionary order." The lecture concludes with a discussion of the fundamental relationship of all kinds of human beings and brief mention of the proposals for regulating the nature of men, ending in a promise later to consider whether "turning man, the unique mammal, into man, the contented cow" is really the most desirable goal.

Lecture three also deals with matters more commonly known to biologists, or at least to those who have given some thought to our population problems. It considers chiefly our success in increasing life expectancy and the resulting change in age distribution in the population.

The Numbers of Men as a title for the fourth lecture scarcely conveys the tremendous implications of the facts concerning the increase of numbers which are discussed in it. During the three centuries for which dependable estimates or accurate data are available, the human species has increased at an almost incredible rate. The author cites H. L. Hawkins' statement that no species has ever yet been able to adapt itself swiftly and skilfully enough to survive such circumstances, and concludes that man's hope of ultimate success rests on "the fact that he has shown himself on occasions to possess somewhat greater innate powers of adaptability than any other organism has known. One wonders at this point what Doctor Pearl would have said of the capacity of the tool-making, talking creature to adapt himself through those powers without bodily change.

The concluding lecture, *Patterns for Living Together*, expresses the thoughts which the author published in an article with the same title in *Harper's Magazine* a year or two after the lectures were delivered. It brings out the essential contrast between the perfect regimentation of the insect society and the individualism of man which is his heritage as a mammal and cannot be completely subordinated to the demands of his social organization, and emphasizes as the price of success in social groups the encouragement of individuals to express their own peculiar talents.

The reviewer's thoughts have led him through a decade to conclusions very like those of Doctor Pearl. This agreement may be merely a basis of approval. On the other hand, conclusions drawn independently from complex data imply by their agreement a fundamental soundness that cannot lightly be dismissed. One cannot hope that a book of this kind will be widely read, particularly by the politicians and labor leaders and industrialists who ought to read it, but it is not exaggeration to say that it strikes at the root of human difficulties and could well be a guide to their solution.—A. W. L.

THE ENTOMOLOGICAL SOCIETY OF AMERICA

PROCEEDINGS OF THE FORTY-FIRST ANNUAL MEETING

Richmond, Virginia, December 9-12, 1946

The Entomological Society of America held its forty-first annual meeting Monday through Thursday, December 9–12, 1946, in conjunction with the annual meeting of the American Association of Economic Entomologists, the Headquarters for the joint meeting being in the John Marshall Hotel, Richmond, Virginia. Attendance for the joint meeting was over 400 and about 300 attended the Entomologists' Banquet.

Monday, Tuesday and Wednesday mornings, the two societies held a joint session, and in the afternoon broke up into individual sessions of the two societies. Monday evening was featured by the annual public address of the Entomological Society of America, and on Tuesday evening the Entomologists' Banquet was held with a guest speaker. The program presented at the four-day meeting follows:

Monday Morning, December 9, 10 A. M.

JOINT MEETING WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLIGISTS

President Muesebeck called the session to order and introduced Dr. Clay Lyle, President of the American Association of Economic Entomologists, who delivered his Presidential Address, "Achievements and Possibilities in Pest Eradication."

At the end of the joint session, the Executive Committee of the Entomological Society held a preliminary meeting.

Monday Afternoon, December 9, 1:30 P. M.

President Muesebeck called the session to order and announced the appointment of the following committees:

Nominating Committee—W. E. HOFFMAN, S. W. FROST, R. E. SNODGRASS, Chairman.

Resolutions Committee—H. L. SWEETMAN, F. W. POOS, Z. P. METCALF, Chairman.

The following papers were presented:

1. The insect cranium and its so-called "sutures" (25 min., illus.), R. E. SNODGRASS, Washington, D. C.
2. Further notes on the behavior of burying beetles (*Nichrophorus* spp.), by title), L. J. MILNE, University of Pennsylvania.
3. The larvae of *Pleocoma* and its systematic position (Coleoptera, Pleocomidae) (10 min., illus.), W. P. HAYES and PEH-I CHANG, University of Illinois.
4. The classification of Coleoptera (20 min.), J. CHESTER BRADLEY, Cornell University.

5. Apicotermes Nests: A remarkable case of behavior evolution (by title), ALFRED E. EMERSON, University of Chicago.
6. Mathematics and Biology, W. R. THOMPSON, Belleville, Ontario, Canada.
7. The flight of the Drone fly (20 min, illus.), C. H. CURRAN, American Museum of Natural History.

Monday Evening, December 9, 8 P. M.

Dr. Frank M. Carpenter, Harvard University, presented the Annual Public Address entitled, "Early Insect Life," illustrated with slide material.

Tuesday Morning, December 10, 9:30 A. M.

JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

President Lyle called the meeting to order and introduced the speakers on the first part of the program:

An entomological survey of the Micronesian Islands, by H. K. Townes and R. G. Oakley, B. E. P. Q.

After discussion on this part of the program, President Lyle turned the program over to J. F. Yeager for the latter part of the program: Insect Physiological Research in Relation to DDT and Other New Insecticides.

Excellent informal discussions of their investigations were presented by Dr. Kenneth D. Roeder, Department of Biology, Tufts College, Massachusetts; Dr. Julian M. Tobias, Department of Physiology and the Toxicity Laboratory, University of Chicago, Illinois, and Dr. Leigh E. Chadwick, Medical Division, Edgewood Arsenal, Maryland. This program was completed in the early afternoon with an interesting discussion by Dr. Daniel Ludwig, Department of Biology, University Heights, New York University. In the afternoon, formal papers on insect physiology were presented at the Physiological Section. A widespread interest in insect physiological work was manifested by the entomologists at both of these sessions.

Tuesday Afternoon, December 10, 1:30 P. M.

Presentation of papers, Physiological Section: J. F. YEAGER, B. E. P. Q., presiding.

8. Electron microscope studies of the structure of isolated cuticular membranes in relation to their use in permeability studies (15 min., illus.), A. GLENN RICHARDS, University of Minnesota.
9. A preparation for the study of factors affecting synaptic transmission in the central nervous system of the cockroach (15 min., illus.), KENNETH D. ROEDER, Tufts College.
10. Certain biochemical changes in the DDT poisoned insect (15 min.), JULIAN M. TOBIAS, University of Chicago.
11. Blood volume in the roach, *Periplaneta americana*, determined by several methods (15 min., illus.), J. FRANKLIN YEAGER and SAM C. MUNSON, B. E. P. Q.
12. Blood volume and chloride level in the roach, *Periplaneta americana*, injected with NaCl solutions (15 min., illus.), SAM C. MUNSON and J. FRANKLIN YEAGER, B. E. P. Q.
13. The effect of peanut oil on the desiccation of *Prometha* pupae (10 min., illus), DANIEL LUDWIG, New York University.

Tuesday, Evening, December 10, 6:30 P. M.

The Entomological Banquet was held in the Virginia Room with an attendance of about 300. At the end of the banquet, J. van der Vecht, Instituut voor Planttenzieken, Buitenzorg, Java, have a most interesting address, "War Experiences of an Entomologist in the Far East."

Wednesday Morning, December 11, 9:30 A. M.

JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

A discussion of the United Nations Educational Scientific, and Cultural Organization (UNESCO), DETLEV W. BRONK, Philadelphia, Pennsylvania.

Preventive Entomology, P. N. ANNAND, B. R. P. Q.

The proposed revision of the Federal Insecticide Act and the need for uniform state legislation, W. G. REED, U. S. D. A., P. M. A.

Wednesday Afternoon, December 11, 1:30 P. M.

Presentation of papers, continued:

14. Tarsal chemoreceptors of the house fly and their possible relation to DDT toxicity (15 min., illus.), W. P. HAYES and YU-SU LIU, University of Illinois.
15. A review of the genus *Atricholaelaps* Ewing, a group of mites parasitic chiefly on rodents (Acarina: Laelaptidae), (15 min., illus.), B. W. STRANDTMANN, University of Texas.
16. Notes on *Melanoplus mexicanus*, its included subspecific units, and related species (15 min., illus.), ASHLEY B. GURNEY, B. E. P. Q.
17. Plastics and standardization technique reform Lepidoptera collections (by title), OTTO ACKERMANN, Irwin, Pennsylvania.
18. Revision of the Naucorid Subfamily Cryphocircinae (15 min., by title), ROBERT L. USINGER, University of California.
19. Review of generic concepts in Corixidae (by title), H. B. HUNGERFORD, University of Kansas.
20. Some new species of Delphacine Fulgorids (by title), R. H. BEAMER, University of Kansas.

Wednesday Afternoon, December 11, 3 P. M.

At the end of this program President Muesebeck opened the annual business meeting of the Society which is reported here at the end of the Presentation program.

Thursday Morning, December 12, 10 A. M.

Discussion section on problems in systematics and nomenclature. This program was planned by R. L. Usinger, University of California, but Dr. Usinger was unable to attend the meeting. In his absence C. W. Sabrosky, B. E. P. Q., presided.

To open the discussion, Dr. A. B. Gurney outlined the problem of the specific units of *Melanoplus mexicanus* and its allies, and President Muesebeck presented a discussion prepared by L. L. Buchanan (who was unable to attend the meeting) on speciation problems in parthenogenetic weevils, especially in the white fringed weevil complex. Discussion on these two papers and ramifications which they suggested continued throughout the session. At its close President Muesebeck adjourned the session and the annual meeting.

Wednesday Afternoon, December 11, 3 P. M.

ANNUAL BUSINESS MEETING OF THE SOCIETY

The meeting was called to order by President Muesebeck and the following business was transacted:

REPORT OF THE SECRETARY

Executive Committee Activities:

The activities of the Executive Committee during the year have already been published in the September, 1946, number of the ANNALS, page 341. Since the time of that report, the Executive Committee has been concerned primarily with planning for the annual meeting. As the time for these approached, a tide of complaints was received from Society members in teaching positions, requesting that every effort be made to hold future meetings during the Christmas recess.

Annual Executive Committee Meeting:

The Executive Committee convened in the John Marshall Hotel for its first session at 11:30 A. M., December 9, and for a later session at 9:30 P. M., December 10. The following members were present: C. F. W. MUESEBECK, H. H. ROSS, S. A. GRAHAM, A. W. LINDSEY, and S. W. FROST. PRESIDENT MUESEBECK designated the following alternates who were also present: Z. P. METCALF, D. M. DELONG, J. C. BRADLEY, and S. W. BROMLEY.

1. Twenty-seven new members were elected as members of the Society, listed in the Section of New Members. The following have resigned during the year: THOMAS GLENN BOWERY, EDWARD L. COMAN, ROBERT H. COOPER, BRUCE D. GLEISSNER, RICHARD H. HANDFORD, NORMA LEVEQUE, ISABEL MCCRACKEN, A. C. MAXSON, ROY H. NAGEL, JOHN C. PRITCHETT, EUGENE M. STAFFORD, and ROBERT A. WARDLE.

2. The following have been automatically dropped as members either because of failure for three or more years to pay dues, or because they cannot be reached: E. J. EPSTEIN, KENNETH GOGEL, I. M. HAWLEY, J. F. T. JODKE, L. C. PETTIT, and G. S. STAINS.

3. The following were elected as Fellows of the Society: F. S. BLANTON, J. S. CALDWELL, H. O. DEAY, P. B. DOWDEN, W. D. FIELD, W. D. MURRAY, C. T. PARSONS, H. D. PRATT, CHARLES SEEVERS, FRANK SHAW, V. M. TANNER, E. S. THOMAS, and H. M. TIETZ.

4. In recognition of his lifetime of service to the Entomological Fraternity and the high quality and constancy of his work, it was moved and seconded that PROFESSOR C. T. BRUES be elected an Honorary Fellow of the Society. Motion carried unanimously.

5. The Society has suffered the loss by death of the following six members. FRANK E. BLAISDELL, GRACE H. GRISWOLD, T. J. HEADLEE, R. H. PETTIT, JOSEPH R. WATSON, and ROSWELL C. WILLIAMS, JR. Following the announcement of these losses to the Society, the members stood in silence in honor of the memory of those who have died in the last year.

6. The following were elected to fill the three vacancies of the Editorial Board: D. J. BORROR, PHILIP GARMAN, and F. H. BUTT. These will serve through 1949.

7. To fill the two vacancies in the Thomas Say Foundation for a period of two years, C. F. W. MUESEBECK and HERBERT H. ROSS were renominated and elected.

8. TIME OF ANNUAL MEETING—In consideration of the fact that some of the uncertainties seem to have been removed regarding transportation and accommodations which existed during the war, it seems feasible to make more definite plans for future meetings of the Society. Dr. Cory, Secretary of the American Association of Economic Entomologists, suggested to your President and Secretary that an effort might be made to have a program somewhat similar to that which was being followed prior to the war and invited the two officers to join an Executive Committee meeting of the A.A.E.E. to discuss such a program.

The following plan was adopted at that meeting as a working basis for future annual meetings, as follows:

1. In consideration of the fact that the members of the two societies having teaching commitments find any time other than the Christmas vacation is a very difficult time to attend the meetings, it was decided to hold them in the future during the Christmas-New Year vacation period.

2. Many members want to meet with the American Association for the Advancement of Science but on the other hand the A.A.A.S. plans to schedule its meetings chiefly or entirely in the northeastern quarter of the country, which is very undesirable from the standpoint of giving impartial service to membership of the two entomological societies. In order to attempt a balance between these two, the following long term schedule is offered for consideration:

1947—Chicago with the A.A.A.S.
1948—New York with the A.A.A.S.
1949—In the South (Jacksonville, Atlanta, New Orleans).
1950—In the West (Kansas City, Denver, Omaha, Des Moines, Salt Lake City).
1951—In the Mid-West (hoping that the A.A.A.S. will meet in this area and being governed by their choice of city—possibly Columbus, Cleveland, Cincinnati or Indianapolis).
1952—In the East again hoping that the A.A.A.S. will meet in the East. (If the A.A.A.S. decides on the East in 1951 and the mid-west in 1952, we should reverse this schedule for 1951 and 1952.)
1953—West Coast—Los Angeles, San Francisco, Seattle.
1954—In the North (possibly a Canadian City, Boston or Buffalo (there is of course the possibility that the A.A.A.S. will be meeting in this area).
1955—In the Southwest (San Antonio, Houston, Dallas or Fort Worth).

As stated by Dr. Cory, "This schedule is flexible as to exact place, provides for at least four meetings with the A.A.A.S., coinciding with their meeting time, and provides that every area in the U. S. may be adequately served. If circumstances that develop determine that it is unwise to go south in 1949, it would be possible and practical to interchange in 1949 and 1950. This also gives local groups a chance to plan a long time ahead in order to make their meeting a success. For instance, the west coast entomologists can determine in which city they want to hold the meeting and then prepare long in advance to make a success of their meeting."

After considerable discussion, the Executive Committee approved this recommendation but added that they did not believe that the dates should be made too definite, depending on circumstances at the time.

9. At this point was brought up the matter concerning a joint committee to prepare a history of entomology in the war effort, as recommended in last year's report of the joint committee on Coordination of Entomology with the War Effort. Following this recommendation it was moved and seconded that the President appoint two members of such a committee to work with two members to be appointed by the A.A.E.E., the committee to choose its own Chairman. Motion carried.

10. Considerable discussion was given to the petition of Joseph W. Enke regarding the role of the Entomological Society in cooperating or directing army and navy work in entomology. It was decided to appoint a special committee to study the possibilities of facilitating entomological activities in cooperation with the army and navy along the lines of proposals 2 and 3 of the petition of Mr. Enke.

11. It was voted to contribute $100.00 to the support of Zoological Record.

12. It was voted to make a contribution of $50.00 to the International Commission of Entomological Nomenclature for the express purpose of aiding the publication of the Bulletin of Zoological Nomenclature.

13. It was voted to continue the current arrangement for the support of the American Committee on Entomological Nomenclature.

Respectfully submitted,

HERBERT H. ROSS, *Secretary.*

There followed additional explanation of the arrangements regarding the future meeting dates. DR. FRACKER requested that consideration be given to meeting with the Phytopathologists during the odd years when the Society did not meet with the A.A.A.S. Following this it was moved and seconded that the Secretary's report be accepted as read. Motion carried.

PRESIDENT MUESEBECK then appointed the committees called for by the adoption of the Secretary's Report. He appointed H. M. HARRIS and F. C. BISHOPP, *Chairman*, a special committee to study the Enke report, and S. W. BROMLEY and P. W. OMAN to serve on the joint committee of two regarding the history of entomology in the war.

TREASURER'S REPORT

MARCH 14, 1946, TO DECEMBER 1, 1946

CURRENT FUND

RECEIPTS

Balance on hand March 14, 1946	$3,320.40
Annual dues	1,845.00
Total	$5,165.40

EXPENDITURES

Annals	$2,500.29
Office expenses, including costs incurred in March meetings	155.41
Checks returned	5.00
Travel expenses	47.56
Zoological Society of London, for Zoological Record	100.05
Total	$2,808.31

PERMANENT FUND

Balance as of March, 1946	$4,596.23
Liberty Bond	50.00
Total	$4,646.23

TOTAL RESOURCES OF SOCIETY

Balance in Permanent Fund	$4,646.23
Balance in Current Fund	2,357.09
Total	$7,003.32

Respectfully submitted,

HERBERT H. ROSS, *Treasurer.*

It was pointed out that the Society's balance was quite favorable, especially considering the fact that the 1947 dues had not started to come in numbers until after the audit was taken. It was moved and seconded that the Treasurer's report be adopted as read subject to approval of the Auditing Committee. Motion carried.

REPORT OF THE MANAGING EDITOR

Since the war is over and the undersigned is completing his second year as managing editor of the Annals, it would be pleasant to report that everything is going smoothly and efficiently with our journal. Unfortunately it is not yet possible to do so. Among the bright spots are the efficient work of Mrs. Helen

S. Lanman, who continues to handle subscriptions and the mailing list in Columbus, and of Miss Doris Cripps, of the Ohio State University mailing room, who handles our addressograph service. The steady influx of excellent manuscripts is also encouraging.

Since last spring the remainder of the back numbers has been transferred to Granville. An attempt to secure lumber for shelving so that a reasonable stock can be made accessible for filling orders has not been successful to date. Steel shelving would be much more satisfactory, but for the present we have released enough shelving in one of the departmental storerooms at Denison to meet the problem temporarily. This expedient cannot be a final solution; we hope that a few more years will make supplies more available so that the Annals stock can be housed in the space originally assigned to it.

The problems of publication are still with us as our members will realize from the extremely late mailing of the September issue, which may not have reached them prior to the annual meeting. The printers are still short-handed and I was told on a recent visit that the supply of paper is still very uncertain. The mills are shipping green paper direct from the machines; their warehouses contain no reserve stock. We have, however, made a satisfying return to the heavier paper which was prohibited during the war. Judging by remarks made to the editor during 1945 this change probably pleases everyone.

We have also made a very satisfactory gain in material for publication. Our accumulated prewar backlog was a great help in maintaining the size of the volumes through the war. It was entirely published, however, and we are now receiving approximately the number of manuscripts needed to publish 700 to 800 pages per year. The editor regards this length as very satisfactory. Whether the Annals may later reach the size of prewar volumes will depend on circumstances, but we need offer no apology for its present state. The existing conditions also enable us to publish much more promptly than before the war, often within three months and usually within six months of the receipt of manuscripts.

The editor apologizes again for delay in returning drawings and cuts. As for the latter, the printers' promise to assemble used cuts has not been fulfilled. We hope that it may be possible soon to bring this work up to date and to render more prompt service when that is once done. Since the time given to the Annals is considerable and the editor also carries the responsibility of heading the largest science department in Denison University, he has to fit his various duties as well as possible into the available hours.

One change has been made in sales policy during the year. Since the stock of reprints is large and the very limited orders for such material can be filled only at a disproportionate cost in time, this service has been discontinued with the approval of the editorial board. Reprints of separate articles are no longer being received. A proposal to Mr. John D. Sherman, Jr., that he take over the stock on hand on a consignment basis was not accepted. His counter-proposal was that we furnish him a complete inventory and permit him to buy outright the salable items. Even this proposal was accompanied by a time limit that made it impossible to consider. The disposition of this stock must be arranged later.

Financially the affairs of the Annals are in excellent condition. The cost of printing has advanced to approximately seven dollars per page, which is still a dollar less than the eastern scientific publishers would charge. This saving, or a large part of it, is probably due to our assumption of editorial work which is handled by such organizations as Williams and Wilkins for many journals. In spite of increased costs, and partly because of the moderate size of the current volume, the Annals account shows a cash balance of $1,501.32 for the ten months since the books were last audited, in contrast with the balance of $948.85 for the preceding thirteen months. Since the printers' bills are paid by the treasurer these figures do not include the portion of the cost defrayed from membership dues. Neither does the current balance include a considerable sum to be collected from authors for cuts published recently. In all we are decidedly solvent and should be able to care for any reasonable increase in the number of pages per volume in the next year or two without financial strain.

In conclusion, the editor reiterates his feeling that the interests of the society would be served better by having the editorship located in an institution with an entomological staff so that more than one man could be familiar with the duties of the office. As long as health permits, however, he values the opportunity to

carry on the work and wishes to thank the many members who have expressed their appreciation to him. He makes no claim to omnipotence but will carry on to the best of his ability as the pressing duty of earning a living permits.

FINANCIAL STATEMENT FOR THE PERIOD
February 1 to November 30, 1946

RECEIPTS

Balance forwarded February 1, 1946	$ 540.30
Balance transferred from Columbus account	872.59
Contribution from Dr. William Procter	500.00
Received from subscriptions	758.00
Sales of back numbers and reprints	50.12
Received from authors for cuts	303.36
Total	$3,024.37

DISBURSEMENTS

Terry Engraving Company	$ 416.48
Spahr & Glenn Company for stationery	27.71
Spahr & Glenn Company for reprints	23.85
Stenographic service	180.50
Addressograph service	21.50
Postage	92.43
Denison University, for telephone and freight charges	3.86
Labor, packing back numbers for shipment to Granville	6.00
Transferred to the Treasurer	750.00
Bank charges	.72
Balance in the Peoples State Bank of Granville, November 30	1,501.32
Total	$3,024.37

Respectfully submitted,

A. W. LINDSEY, *Managing Editor.*

It was moved and seconded that the report of the Managing Editor be adopted as read subject to approval of the Auditing Committee. Motion carried.

REPORT OF THE EDITOR AND TREASURER OF THE THOMAS SAY FOUNDATION

Referring to the reports of The Thomas Say Foundation for 1944 and 1945, one notices that previous to 1944 the publication of the first three volumes was possible only through sales. In 1945, $2,099.42 was obtained from the late W. S. Blatchley and $1,000.00 from Dr. Julius Hyman, late President of the Velsicol Corporation. As a result, the Foundation is now able to publish Volume IV.

A manuscript prepared by David G. Hall on the "Blow Flies of North America" has been in the hands of the Foundation for about three years, but it has been impossible to find a suitable publisher who could handle it because of paper and labor shortages. However, a publisher was obtained this summer, but because of further shortages publication has been slow and delayed. The volume should be available in the near future.

The financial report follows:

RECEIPTS

Balance on hand, March 1, 1946	$3,734.32
1946 sales of Volume I— 3 @ $3.00	9.00
1946 sales of Volume II— 2 @ $5.00	10.00
1946 sales of Volume II— 9 @ $4.50	40.50
1946 sales of Volume III— 3 @ $4.00	12.00
1946 sales of Volume III—14 at $3.60	50.40
Interest to June 30, 1946	17.55
Total Receipts	$3,873.7

EXPENDITURES

Express on Manuscript	$ 1.33	
Postage	4.19	
Three sets of electrotypes for Volume IV	225.00	
Total Expenditures		$ 230.52
		$3,643.25
Due from 1946 sales	$ 16.60	
Balance in Purdue State Bank, December 1, 1946		$3,643.25

Respectfully submitted,

J. J. DAVIS, *Editor and Treasurer.*

It was moved and seconded that the report of the Editor and Treasurer of the Thomas Say Foundation be adopted as read subject to approval of the Auditing Committee. Motion carried.

REPORT OF THE AUDITING COMMITTEE

We, the undersigned, beg to report that we have examined the accounts of the Treasurer of the Entomological Society of America, the Editor of the Annals of the Society, and the Treasurer of the Thomas Say Foundation and have found them to be balanced and correct as of December 1, 1946.

The accounts of the Treasurer, H. H. Ross, were examined by Wm. P. Hayes; those of the Editor, A. W. Lindsey, by R. L. Robb, and those of the Treasurer of the Thomas Say Foundation by George E. Gould.

Respectfully submitted,

GEORGE E. GOULD,
R. L. ROBB,
WM. P. HAYES, *Chairman.*

It was moved and seconded that the report of the Auditing Committee be accepted as read. Motion carried.

DR. S. B. FRACKER, who represented the Entomological Society at a meeting called by the National Research Council to consider the projected Institute of American Biologists, gave an informal report on the subject. He said that only preliminary ideas had been formulated as yet but that the National Research Council would undoubtedly proceed with the matter further in the near future.

The subject of DR. DETLEV W. BRONK'S morning address on UNESCO was discussed, particularly with the thought that mutual benefits might accrue to UNESCO and the Society by cooperative action. It was moved and seconded "that the Secretary be instructed to contact the Secretary of the American Association of Economic Entomologists and Dr. D. W. Bronk, and work out a procedure for joint representation of the two entomological societies to work with the National Research Council on entomological matters pertaining to UNESCO." Motion carried.

REPORT OF THE COMMITTEE ON RESOLUTIONS

1. The members of the Entomological Society of America wish to express their appreciation to the Committee for Local Arrangements: P. D. SANDERS, *Chairman*, G. T. FRENCH, R. W. BRUBAKER, W. E. BICKLEY, R. B. ARNOLD, and J. P. VINZANT, and to the officers of the Society for their efforts and successful planning for this meeting in the face of extreme difficulties; to the officers and members of the American Association of Economic Entomologists for their splendid cooperation; and to the members of the Committee on Local Arrangements at Pittsburgh: A. C. MILLER, *Chairman*, H. G. GUY, ARNOLD MALLIS, and G. E. WALLACE, who spent much time and effort in planning for that meeting.

2. We express our gratitude to the management of the John Marshall Hotel for the facilities so freely made available to us, and to the William Penn Hotel in Pittsburgh for their close cooperation in planning for that meeting.

3. We express our appreciation to DR. FRANK M. CARPENTER, DR. J. VAN DER VECHT, and DR. D. W. BRONK, who have so delightfully addressed our Society.

4. Since during the past year our Society has lost several members through death, we wish to express our appreciation and instruct our Secretary to send our expression of sympathy to the families of each deceased member.

5. DR. WILLIAM PROCTER has again generously contributed a sum of $500.00 to the Annals of the Entomological Society of America for the year 1946–7 and we wish to express to him sincere appreciation of the Society for his generous confidence and support.

Respectfully submitted,

HARVEY L. SWEETMAN,
F. W. POOS,
Z. P. METCALF, *Chairman.*

On motion this report was adopted as read.

REPORT OF THE NOMINATING COMMITTEE

This committee places for nomination the following Fellows of the Entomological Society of America for the officers of the Society for the year 1947:

President.....Z. P. METCALF
First Vice-President.....ROGER C. SMITH
Second Vice-President.....E. GORTON LINSLEY
Secretary-Treasurer.....HERBERT H. ROSS
Executive Committee.....J. F. YEAGER, A. GLENN RICHARDS

Councilors to the American Association for the Advancement of Science—CLARENCE E. MICKEL, University of Minnesota, St. Paul, Minnesota, and WILLIAM P. HAYES, University of Illinois, Urbana, Illinois.

Respectfully submitted,

W. E. HOFFMAN,
S. W. FROST,
R. E. SNODGRASS, *Chairman.*

After reading of the above report, DR. J. C. BRADLEY was nominated from the floor for the office of First Vice-President. After a call for further nominations, it was moved and seconded that the Secretary cast a unanimous ballot for the offices of President, Second Vice-President, Secretary-Treasurer, and two members of the Executive Committee, and that a ballot be taken on the post of First Vice-President. Motion carried. The designated ballot was taken and Dr. R. C. SMITH was elected.

AMERICAN COMMITTEE ON ENTOMOLOGICAL NOMENCLATURE

The activities of the American Committee on Entomological Nomenclature, since the annual meeting in March, 1946, had three distinct phases. These included the study of certain problems submitted by individuals for Committee consideration, the undertaking of certain broad studies of nomenclatural problems, and a revision of the By-Laws under which the Committee operates.

Among the subjects submitted to the Committee by various individuals and now under Committee investigation with a view to advisory action and possible representations to the International Commission on Zoological Nomenclature are: (1) Misidentified genotypes, (2) The status of names placed on "The Official List of Genetic Names in Zoology," (3) The valid name of the Dipterous family Ortalidae *auctt.*, and (4) The status of generic names published after December 31, 1930, without definite unambiguous designation of the type species and certain problems related thereto.

The broader nomenclatural studies initiated by the Committee itself include (1) a study of family names of American Insects, (2) a survey of proposals pending before the International Commission on Zoological Nomenclature with a view to obtaining an expression of Committee opinion on matters pertinent to entomological nomenclature for transmissal to the Secretary of the International Commission, and (3) the preparation of a proposal or series of proposals to the International Commission on Zoological Nomenclature regarding the nomenclature of categories of less than subspecific rank.

The Committee also revised and amended its By-Laws. The revised By-Laws follow:

NAME.

1. The name of this Committee shall be the American Committee on Entomological Nomenclature.

SPONSORSHIP.

2. The Committee exists under the joint sponsorship of the Entomological Society of America and the American Association of Economic Entomologists, to each of which it shall be equally responsible.

OBJECTIVES.

3. The objectives of this Committee shall be:

a. To initiate or to further action tending to stabilize the nomenclature of American insects.

b. To make recommendations directly to the International Commission on Zoological Nomenclature or through the International Commission on Entomological Nomenclature on cases involving action of interest to entomologists.

c. To give advice on problems of nomenclature that may be submitted to the Committee by any American entomologist.

LIMITATION.

4. The Committee in all its actions shall be bound by the International Code of Zoological Nomenclature and by the Opinions of the International Commission on Zoological Nomenclature.

MEMBERS.

5a. The Committee shall consist of nine members.

5b. Three members shall retire each year but shall be eligible for re-election. The term of office of a retiring member shall end at the close of the Annual Meeting.

5c. At least two names shall be placed in nomination for each vacancy by the Chairman.

5d. Members shall be elected annually by a majority vote of the Committee, but shall be subject to confirmation by the executive committee of each sponsoring organization. The election shall be by mail ballot and shall be completed not less than one month prior to the Annual Meeting.

5e. Ballots for members shall be sent to and tallied by a member of one of the sponsoring organizations to be designated by the chairman

OFFICERS.

6a. The officers of the Committee shall be a chairman and a secretary.

6b. It shall be the duty of the chairman to preside at meetings and to initiate any action, including the appointment of subcommittees, looking towards the fulfillment of the objects of the Committee.

6c. It shall be the duty of the secretary to carry on official correspondence, mail ballots, arrange for the preparation of reports and summaries of committee action, render an Annual Report to the Committee for transmission to the two sponsoring organizations, and transact other business.

6d. The officers shall be elected annually by a majority vote of the Committee, the election to be by mail ballot and completed not less than one month prior to the Annual Meeting. Election of a retiring member to office shall be tantamount to re-election to membership on the Committee. Newly elected officers shall take office at the close of the Annual Meeting.

6e. Ballots for officers shall be sent to and tallied by a member of one of the sponsoring organizations to be designated by the chairman.

TRANSACTION OF BUSINESS.

7a. The Committee shall be empowered to make such rules as may appear desirable for the handling of its business.

7b. Action on matters of nomenclature shall be taken by mail ballot, except that final action on written summaries of matters previously submitted for consideration may be taken at the Annual Meeting.

7c. Decisions on matters of nomenclature shall require a majority vote of the Committee, but when the vote is divided five to four the secretary shall submit the case for reconsideration by the Committee. If after reconsideration the vote remains the same, the case shall be submitted to the International Commission on Zoological Nomenclature.

7d. Termination of vote on matters submitted to the Committee by mail shall be upon receipt of five votes that agree, except that the vote shall not be terminated in less than 30 days from time of mailing of ballots unless all votes are in.

PUBLICATION.

8. Decisions of the Committee shall be published in summary form, or with such additional explanatory remarks as may be deemed appropriate, in the Annals of the Entomological Society of America under the name of Advisory Recommendations.

QUORUM.

9. A quorum at any meeting shall consist of a majority of the members of the Committee.

AMENDMENT.

10. These By-Laws may be amended by a majority vote of the Committee taken by mail ballot.

Respectfully submitted,

E. G. LINSLEY, *Secretary.*

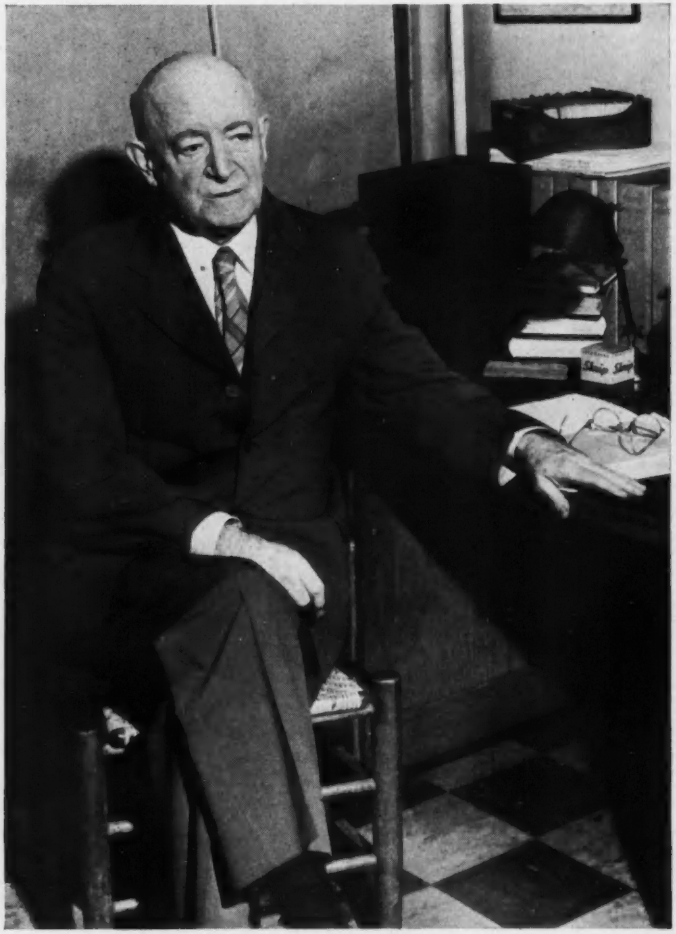
On motion this report was adopted as read.

Following the call for further business, President Muesebeck declared the meeting adjourned.

NEW MEMBERS

BARTHOLOMAI, C. W., 201 Post Office Bldg., Hutchinson, Kansas.
BYARS, L. FREELAND, P. O. Box 1595, Nogales, Arizona.
CAMPBELL, D. K., Box 308, Vernon, British Columbia, Canada.
CAZIER, MONT A., American Museum of Natural History, Central Park West at 79th, New York 24, New York.
CONNIN, RICHARD V., 515 Meyers Street, Toledo 9, Ohio.
DETHIER, VINCENT G., Dept. of Entomology, Ohio State University, Columbus, Ohio.
HERSHBERGER, RUTH V., Dept. of Entomology, Ohio State University, Columbus 10, Ohio.
HILCHEY, JOHN DUNCAN, Fernald Hall, Massachusetts State College, Amherst, Massachusetts.
LAHUE, DELMON W., P. O. Box 54, Swanton, Ohio.
LANHAM, URLESS N., Div. of Entomology and Parasitology, University of California, Berkeley, California.
MALKIN, BORYS, University of Oregon, Dept. of Anthropology, Eugene, Oregon.
MENDER, MANUEL BARRO, Calle 12 Nr. 220, Altos, Apart 3, Vedado, Habana, Cuba.
OWEN, ROBERT P., 401 Washington Avenue, Brooklyn, New York.
PECK, OSWALD, Div. of Entomology, Dept. of Agriculture, Confederation Bldg., Ottawa, Ontario, Canada.

QURAISHI, M. SAYEED, 15 Hallock Street, Amherst, Massachusetts.
REDLINGER, LEONARD M., 1015 Thurston, Manhattan, Kansas.
SCUDDER, HARVEY T., 284 James Street, Teaneck, New Jersey.
STANNARD, LEWIS J., JR., Dept. of Entomology, University of Illinois, Urbana, Illinois.
STRONG, RUDOLPH G., P. O. Box 1538, State College, Mississippi.
TRAVASSOS, LAURO P., Dept. de Zoologia, Sec. da Agricultura, C. postal 172-A, São Paulo, S. P., Brasil.
WALLACE, HERBERT S., Dept. of Entomology, University of Kansas, Lawrence, Kansas.
WELLHOUSE, WILLIAM T., 1113 W. Tenth Street, Lawrence, Kansas.
WERNER, FLOYD G., 702 Pearl Street, Ottawa, Illinois.
YANCEY, ROBERT M., Dept. of Entomology, Oregon State College, Corvallis, Oregon.



CLARENCE HAMILTON KENNEDY